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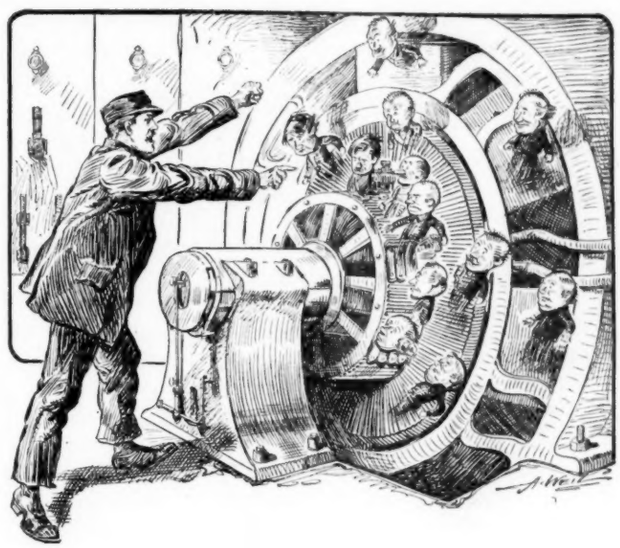
The Generator's Grievance

A FABLE—BY EARL PAGETT

"I have to do all the work and I am tired of it, so I am going to quit," said the Armature Coil. "I have to be whirled around at a high rate of speed until I am dizzy-headed, and I make every ampere that is turned out by this whole machine. I don't get proper credit for it, and you fellows can all be hanged; I am done with this crowd."



"Hold!" chimed in the Field Coil. "Don't be so smart. Never an ampere could you make if I didn't furnish you a nice, strong magnetic flux to turn in. You wouldn't be worth the room you take if it wasn't for me. I am the one that you all depend upon, and little credit do you give me."

"Stop!" roared the Commutator. "It makes no difference how much you both do; it would all come to naught, were it not for me."

"Cease, all of you!" squeaked the Brush. "It is very plain that it is all up to me. Every bit of energy generated by you fellows has to pass through me before it can get out on the wires to accomplish its purpose."

Thus they wrangled and argued with one another and would have come to blows had not the Chief looked at the switchboard and noticed that old No. 6 generator was not doing any work. He appeared quickly on the scene.

"What's the matter with you, Field Coil? What's the matter with you, Armature Coil, and all the rest of you?"

"They were about to fight over who did the most work and who was the most important. Each thinks that the credit is due him," piped up the Brushholder, who had taken no part in the argument.

"Is that all?" resumed the Chief. "Now listen to me. Each of you fellows has his part of the work to do, and each knows his work. Now get busy. If I hear any more of this growling, I will pluck all of you out and put new parts in this machine that are willing to do all they can."

Whereupon each of them saw things in a different light. The old machine took on new life and began to purr, and the hand on the ammeter swung immediately to full-load position.

Moral: Pull Together

Operating Mechanical Stokers

By Warren O. Rogers

SYNOPSIS—General instructions for handling chain-grate stokers, such as starting the fires, banking and other operating details that those engaged in handling this type of stoker should know.

There are three general classes of automatic stokers—the traveling grate, the overfeed and the underfeed. In the matter of combustion efficiency, other conditions being equal, there is but little if any appreciable difference with the various types of stokers, the only provision being that the proper kind of stoker is installed for the grade of fuel used and the conditions of operation to be fulfilled.

In the modern power plant the tendency is toward increased overloads, high efficiencies and smokeless-furnace operation. This has resulted in a number of stoker designs, the operation of which is more or less understood by engineers and firemen.

The instructions relating to stoker operation in this and following articles have been compiled from the various rules issued by the several manufacturers of automatic stokers, together with other general information relating to the subject. Although the operation of stokers is simple in many respects, no strict rules can be given for handling them, and their success and efficiency depend a great deal upon the care, attention and judgment of the operator.

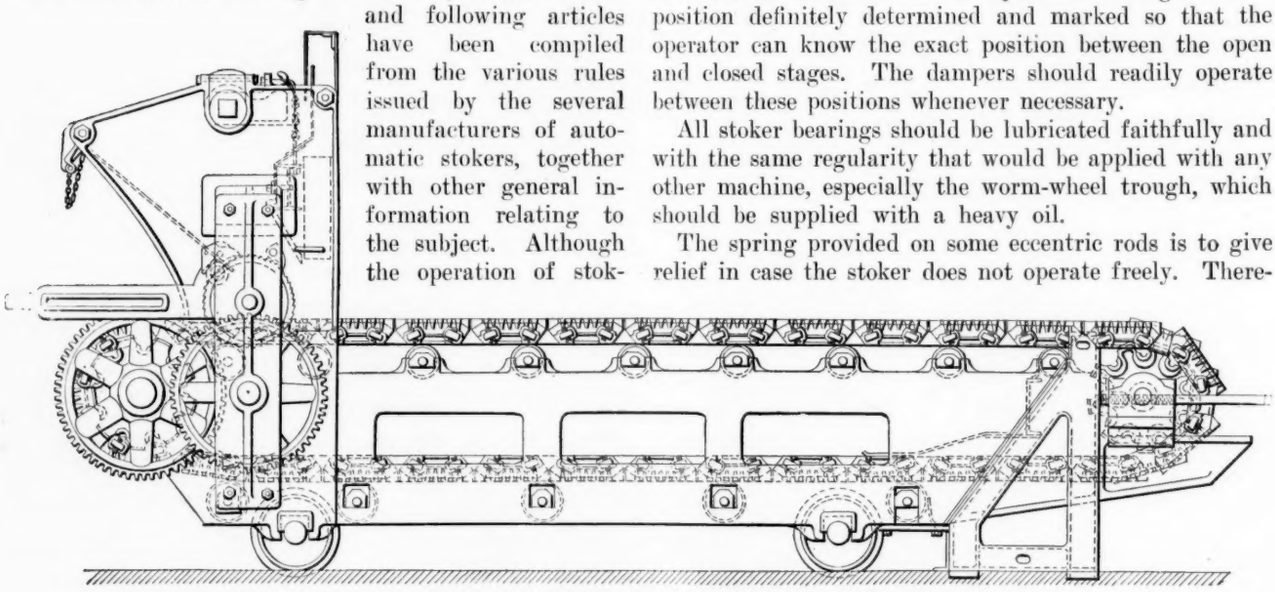


FIG. 1. A LONGITUDINAL VIEW OF A CHAIN-GRATE STOKER

There are numerous classes of coals which require different treatment or handling in order to successfully burn them. There are free-burning or coals easy to ignite, slow-burning or slow to ignite, and then there are fine coals which require more draft and a thinner fuel bed than larger-sized coal of the same quality. Traveling chain-grate stokers have been successful in burning a certain class of bituminous coal with 30 to 40 per cent. volatile matter and ash ranging from 10 to 20 per cent.

Generally one operator and one coal passer can handle about 10 chain-grate stokers. This type of stoker is high in forcing capacity, because forced as well as natural draft can be employed, but with certain kinds of fuel forced draft has not been altogether successful. Chain-grate stokers are generally large in area for the boiler when compared with other types of stokers, and the normal forcing capacity will average 260 per cent. of the boiler rating, with the combustion rates up to 48 lb. per square foot of grate surface, with coal that is suitable for the stoker. With coals low in ash, this rate of driving would cause the grate to become overheated and high maintenance costs would be the result. Therefore the chain-grate stoker is best suited for coals high in ash when the boilers are to be operated at a high rating. The average price per rated boiler horsepower is between $3.50 and $6.55. The maintenance per ton of coal consumed is between 6 and 10 cents.

All chain-grate stokers (Fig. 1) operate on the same general principle, and with the exception of a few minor matters the following instruction as to their operation will apply to practically all designs. In order to obtain the best operating results it is essential that the draft be under control and that all boiler dampers be examined at intervals and the "wide open" and "tight shut" position definitely determined and marked so that the operator can know the exact position between the open and closed stages. The dampers should readily operate between these positions whenever necessary.

All stoker bearings should be lubricated faithfully and with the same regularity that would be applied with any other machine, especially the worm-wheel trough, which should be supplied with a heavy oil.

The spring provided on some eccentric rods is to give relief in case the stoker does not operate freely. Therefore, it should be adjusted to permit a full turn of the eccentric without moving the grate. The speed of the eccentric shaft should not exceed 35 r.p.m. with normal operation. The chain tension should be reasonably tight. If it is loose, adjust it by screwing up the tension screws (Fig. 2) on each side until they have taken all the slack out of the chain. When the screws can hardly be turned with, say, an 18-in. wrench and the ratchet arm works hard and both sides are so tightened, relieve each side slightly until the ratchet arm will freely move the grate when worked by hand. This adjustment should be made as soon as it is noticed that the links tend to dip after leaving the front sprockets.

All gate-leveling bolts can be adjusted to obtain a uniform fuel bed, but before adjusting these bolts to correct an uneven fire be sure that it is due to the gate being out of level and not to other causes.

A broken link should never be permitted to remain in the chain; it should be replaced at once. Some settings provide definite arch ventilation, and the openings left through the side walls and curtain walls therefore must be kept clear and indicate definite air circulation.

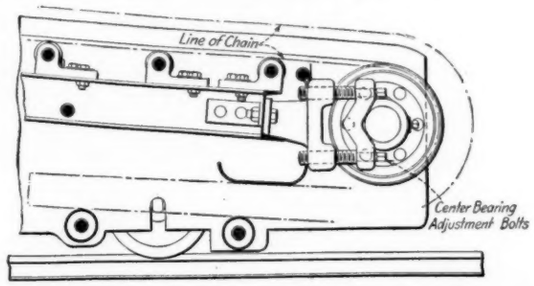


FIG. 2. TENSION SCREWS FOR TIGHTENING THE CHAIN GRATE

In some stokers adjustable ledge-plate flanges are provided, and if disturbed by the brickwork settling, they should be again set within $\frac{1}{8}$ in. of the stoker chain, so as to cut off air leaks between the chain and the furnace side walls.

When starting a fire, first open the waterback valves, if a waterback (Fig. 3) is used, and insure a definite flow of water through it. The discharge pipe from the waterback should never become too hot to be held by the bare hand; the amount of water can be controlled by adjusting the inlet valve. Then raise the fuel feed gate about 6 in. and remove the hopper plate which forms the front wall of the hopper and cover the grate with about 4 or 5 in. of coal for three-quarters of its length. If no power is available, use the hand crank to move the fuel bed toward the rear of the grate. The more of the grate surface that is covered, the quicker steam can be raised. Then put sufficient wood (free from nails and metal) and oily waste or shavings on top of the coal (Fig. 4) and start the fire at the front of the grate outside of the feed gate with pieces of oily waste, so that it will burn back onto the grates. If the stoker has dampers, close them under that part of the grate not

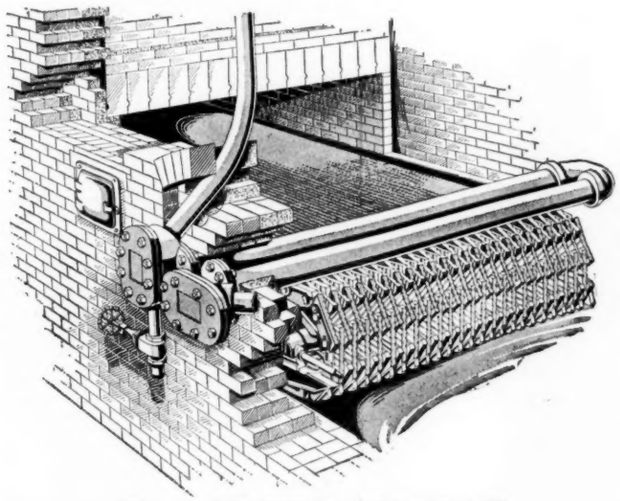


FIG. 3. ONE TYPE OF WATERBACK

covered with coal. When the kindling is ignited, run more coal into the hopper to stop any air from getting in over the fire and under the arch. Gradually the arch will become heated and the coal in the furnace ignited.

In place of kindling, burning coals from some other furnace may be used. In this case, about five feet of coal should be run into the furnace and the hopper left empty. The live fire should be distributed along the edge of the gate and should be covered with some coal in the hopper, in order to avoid air rushing in over the fire. The grate may then be occasionally worked, at first slowly, and when the coal is thoroughly ignited, continue the operation with increased draft. The secret of starting the fire quickly is to get the arch hot.

Before starting the stoker be sure that the fire is burning for the full width of the grate, meanwhile keeping the opening under the feed gate covered with coal so that all the air will go up through the grate. Keep the grate stationary until all the coal on it is ignited. Then put in the hopper plate and fill the hopper with coal and set the speed regulator at the slowest speed and maintain this speed until the fire at the rear end of the grate is burning briskly. At the time of starting the fires, have the damper in the stack open about half way. The fire should not be forced at first as the brickwork and arches

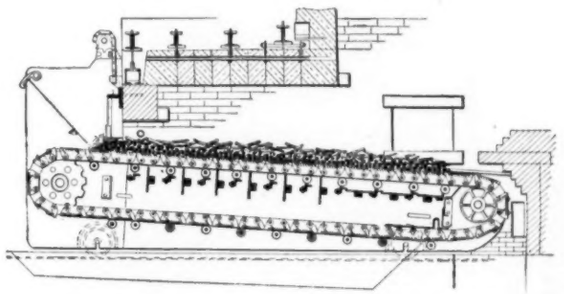


FIG. 4. GRATE COVERED WITH COAL AND WOOD LAYER ON TOP

should be given a chance to become gradually heated, and at least an hour should elapse before any attempt is made to force the fire sufficiently to raise steam on the boilers. On a new installation or where the brickwork in the furnace has been replaced, two or three days of a slow drying-out fire should be used before attempting to maintain sufficient fire on the grates to raise steam.

In order to have the grates operate efficiently, no unconsumed fuel should be carried over the end of the grate and frequent analyses of the flue gases should be made. After a few days' experimenting with different thicknesses of fuel bed and speed of the grate, it will be easily determined what is the correct combination for properly burning the particular coal being used at the time. See that all air openings around the front and side of the stoker are effectually closed, as the efficient operation of the stoker depends upon all the air for combustion passing through the fuel bed and not over the top of the fire, as will be the case if there are air leaks.

If the fire tends to draw away from the gate, feed slower, decrease the thickness of the fuel or adjust the damper. The thickness of fuel bed is shown on the gate indicator.

Variation in gate height is necessary with coals varying in fineness and in volatile proportions. It is better to run with thick fires slowly rather than with thin fires fast. The average speed of the grate should be about $3\frac{1}{2}$ in. per min. Keep the grate covered by closing the dampers and slowing down the stoker with decreasing load and vice versa with increasing load. Keep the

bottom side of the feed gate tile in line. An uneven fuel bed makes an uneven fire, and the thing to do is to insert new tiles when the old ones are burned or broken off, Fig. 5. Dampers should not be entirely closed during operation, and a furnace draft of one-tenth inch should be the lowest draft permitted.

If the fire tends to pass over into the ashpit (Fig. 6), the grate is not operated properly and is feeding the fuel too fast, or too thick, or the furnace is given insufficient draft. With proper feed and draft, and when fired with free-burning coal, the grates should be covered with fire, but the fuel should be consumed upon reaching the rear turning point. Do not allow the back end of the grates to become bare of live coals (Fig. 7) or the efficiency of the furnace will suffer, because air will pass through the grates and retard combustion.

Adhesions usually form on the inside of side walls. About once in six hours run a bar in under the hopper apron and gate, being careful not to dislodge the gate tile. This should be repeated regularly as often as need be to keep side walls clean and to prevent the side links

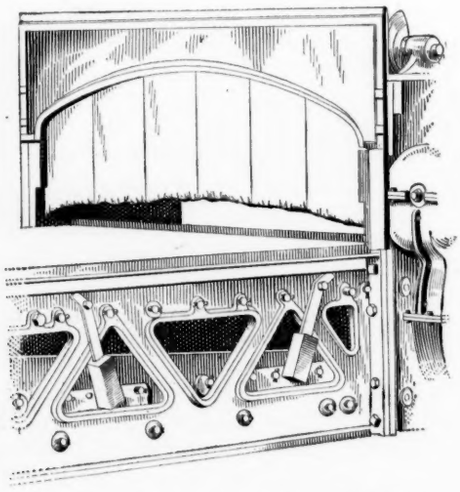


FIG. 5. BURNED TILE IN FEED GATE

on the stoker from being burned out. The frequency of the operation depends on the character of the coal.

All ashes should be kept out of the ashpit and not allowed to accumulate so as to pile up around the chain, with some designs of pits, and possibly burn it out. Neither should the drippings of coal through the grate be allowed to accumulate, and whenever the drippage pan is partly filled, remove the coal from it and put it back into the hopper a little at a time. A large amount will make holes in the fire. It is not a bad plan to wet the drippings. Do not stop the stoker for any length of time with the hopper full of coal, as under such a circumstance the fire will burn forward and injure the gates. Do not run short fires with the damper wide open, as this results in high brickwork maintenance and poor economy. Do not try to regulate the fires by opening the doors in the stoker setting. Be careful in washing out the boiler that the waste water does not run upon the stoker arch, as nothing is more injurious to its lasting qualities than water; therefore keep the arch dry.

If the fuel is a coking coal, it will be necessary to run a slice bar through the bed of fire occasionally to break up the fuel in order to allow the free passage of air through the fuel bed.

If the grate is run at such a speed that no unconsumed fuel runs through the end of it, the links will be cool enough to allow placing the hand on them before the chain enters beneath the hopper. The speed should also be such that all the volatile matter in the coal is driven

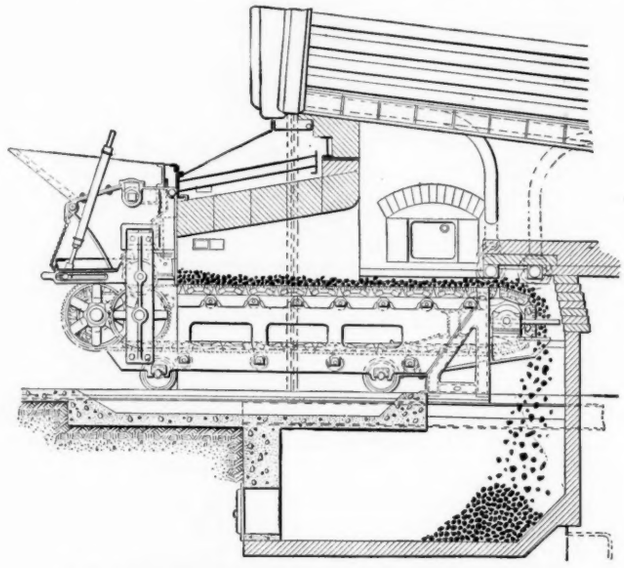


FIG. 6. FUEL GOING TO ASHPIT, DUE TO TOO FAST FEEDING

off by the time the coal has traveled not more than half the length of the grate.

Varying loads can be easily taken care of by proper regulation of the thickness of fuel bed and the speed of the grate. The damper opening will, of course, have to be regulated accordingly. Insufficient draft will cause smoke in the stack and possibly in the feed hopper. If smoke is noticeable in the feed hopper, allow it to empty

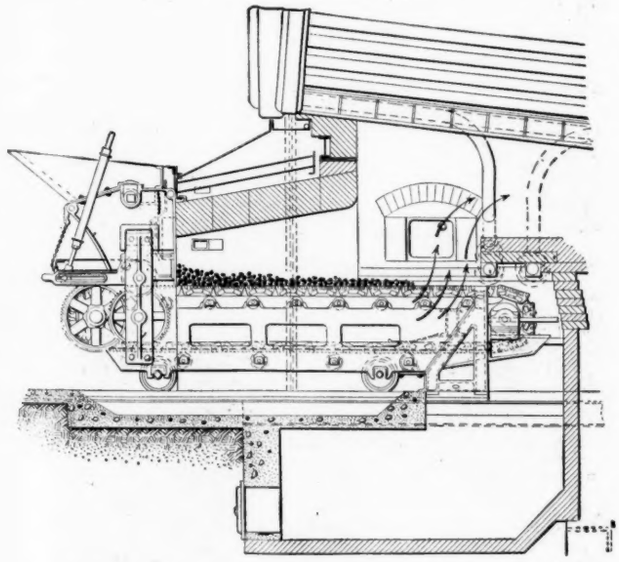


FIG. 7. AIR PASSING THROUGH BAND PORTION OF GRATES

itself and inspect the feed-gate shoes to determine whether they are being burned. If so, allow the hopper to remain empty until the shoes cool off.

To force the fire, open the boiler damper wide, speed up the grate, lower the feed gate and loosen up the

coal. To do the last introduce a $\frac{3}{4}$-in. diameter bar having a right-angle bend 6 in. long at the end. Run the bar through the furnace with the 6-in. leg flat on the grate. When it is at the rear of the grate, turn the bar completely over and pull it out. Continue until the whole grate has been gone over. Never disturb the top surface of the fuel bed; just loosen the coal next to the grate.

To bank the fire, let the hopper become empty, stop the grate and pull the damper partly shut, so as to allow $\frac{1}{10}$ in. draft in the furnace until the fire burns short, then pull the damper almost to the smoking point. Raise the gate as high as possible and run in about one foot of coal. Loosely bank the coal against the lower edge of the gate, allowing a little air to get through. At intervals of perhaps five hours run the grate ahead a little.

To bring a banked boiler up to rating, run a bar under the gate and break up the fuel bed, which has a tendency to cake during banking. Partly open the damper, lower the gate to the operative point, fill the hopper and as soon as the arch is thoroughly heated, start the stoker at a rate that will keep the fuel ignited at the gate. When the grate is completely covered, the damper may be opened wide and normal operation begun.

If the ash and slag are automatically discharged upon a dump plate, they must be dumped into the ashpit periodically by operating a hand rod.

In order to know that there are no air leaks, the boiler settings should be tested with a candle or kerosene torch for air leakage. Furthermore, keep all doors and openings around the boiler setting closed.

As a matter of precaution against injury use care in throwing in and out the driving pawls and in changing the speed of the stokers so equipped. Always stop a stoker engine, motor or other drive when it is necessary to adjust, repair or work around any of the moving parts, such as the ratchet drive, etc.

Cleanliness in the Power Plant

The accompanying photograph is an illustration of what may be done to beautify the power plant. The view was taken in the engine room of the Flint & Walling Manufacturing Co., of Kendallville, Ind. In the words of H. H. Macomber, president of the company: "The engineer is a man who enjoys doing everything well and takes pride in keeping his plant in the best possible condition. Although the management furthers the desires of the engineer in a substantial way, the credit for the neatness and general attractiveness of the plant is his, for it was his initiative and constant attention that made it possible. The caring for the plants means a lot of extra work. They have to be removed every spring to their outdoor locations, returned every fall, watered and trimmed and cared for as a florist would do. The expense of maintaining and

ENGINE ROOM OF THE FLINT & WALLING MANUFACTURING CO.

mixing a little of nature's beauty with the power plant is insignificant compared to the pleasure it gives us and all who enter the station."

The engine room is well lighted, the interior walls and floor are neatly painted and the brasswork highly polished. In the boiler room, containing two 500-hp. hand-fired water-tube boilers, a feed-water heater, water softener, feed pumps and other equipment, there is the same devotion to cleanliness. The walls and the boiler settings are painted white. There is practically no dirt or dust on the piping, and the same applies to the boiler tops, where it is customary to see an accumulation inches deep. The piping is neatly arranged, firing tools have a place and are kept there, and a pool of dirty water or oil is an unusual sight. In fact, there is little room for improvement in its general appearance.

Such attention to outward attractiveness augurs well for the interior condition of the equipment. It is generally conceded that a clean, well-lighted plant has a good influence on the men, resulting in lower production costs. In the present case it is safe to assume that the boiler tubes are kept free of scale and soot, that efficient combustion results from clean fires and ashpits, that the settings are maintained air-tight and that all equipment in both engine and boiler rooms is inspected regularly, overhauled when necessary and maintained in prime condition.

Systematic inspection and cleaning reveal defects before they become serious, affording those opportunities for "the stitch in time" that tend to lower maintenance charges and prolong the life of the equipment.

From a financial point of view then, cleanliness pays. It adds to the efficiency and self-respect of the men, and as evidenced in the present case, improves their status with the management. In the successful operation of a power plant it is the first essential.

Bleeding Turbines To Heat Feed Water

By H. F. Gauss

SYNOPSIS—Theoretical gain in economy by bleeding steam from intermediate stages of a turbine for heating feed water in an open heater. An arrangement of closed heaters for this purpose. The idea has been applied to triple-expansion pumping engines.

A careful analysis of the advantage to be gained by bleeding steam from an intermediate stage of a steam turbine indicates that unless considerably more steam is bled than that required to heat the feed water used by the unit itself, the saving is not so great as might be expected. This fact may be brought out clearly by a concrete illustration. Assume the following turbine and operating conditions:

1.	Horsepower of turbine	2,000
2.	Steam pressure, lb. abs	175
3.	Superheat, deg. F	100
4.	Exhaust pressure, lb. abs	0.5
5.	Pressure of bled steam, lb. abs	17.7
6.	Pressure auxiliary exhaust, lb. abs	17.7

The Rankine efficiency, or more properly, the efficiency ratio, will be considered constant throughout all stages; that is, it will be assumed that the turbine converts as much of the available heat into work in the high-pressure stages as in the low-pressure stages. This assumption is not strictly correct, as has often been pointed out (see *Power*, Feb. 13, 1917, p. 213), but for the present purpose is sufficiently accurate, and besides, the figures would have to be modified to suit any other particular case. The condensate from the condenser will be passed through a primary heater in the condenser, where it will be raised in temperature to within 3 deg. of the temperature corresponding to the vacuum; namely, 80 — 3 = 77 deg. F. From this primary heater the condensate will pass to the open heater, when it will mingle with the exhaust steam from the auxiliaries and the steam bled from the turbine. Fig. 1 illustrates the arrangement diagramatically. In each pound of initial steam at 175 lb. abs. and 100 deg. superheat there are 1253 B.t.u. Assuming adiabatic expansion, the heat available for work during expansion from 175 lb. abs. down to 17.7 lb. abs. is 180 B.t.u. per lb., and that available for work during expansion from 175 down to 0.5 abs. is 379 B.t.u. Let X represent the amount of steam bled from the high-pressure stages of the turbine. The horsepower developed by the steam before it leaves the turbine is

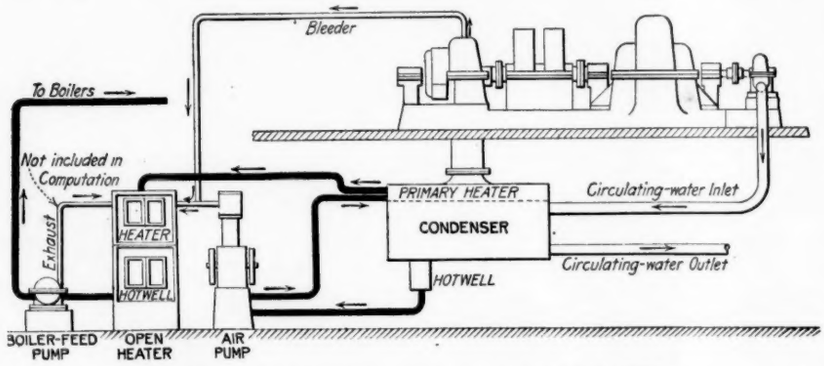


FIG. 1. BLEEDING STEAM TO OPEN HEATER

$$Hp_1 = \frac{X \times 180}{2546} \times 0.65 \qquad (1)$$

where

Hp_1 = Horsepower from bled steam;
X = Pounds of steam bled per hour;
180 = B.t.u. available for work per pound of steam bled;
2546 = B.t.u. equivalent to 1 hp.-hr.;
0.65 = Rankine efficiency.

The steam passing entirely through the turbine is:

$$S = \frac{(2000 - Hp_1) \times 2546}{379 \times 0.65} \qquad (2)$$

where

S = Condensate from condenser per hour;
2000 = Total horsepower of turbine;
379 = B.t.u. available for work per pound of steam.

There will be about 500 lb. of auxiliary exhaust steam available per hour. So low a figure for auxiliary steam can be realized by driving the circulating pump from the main turbine shaft through a reduction gear and employing an Edwards air pump. The power required to drive the circulating pump then becomes part of the 2000 hp. delivered at the turbine coupling.

This auxiliary steam will be at the same pressure as the bled steam and will be assumed to contain the same heat per pound; namely, 1073 B.t.u., which is the heat remaining after adiabatic expansion from 175 lb. abs., 100 deg. superheat, to 17.7 lb. abs. The heat available for heating feed water, then, is that in the bled steam plus the auxiliary exhaust and may be written $(X + 500) \times 1073$ B.t.u. per hour, being measured above 32 deg. F.

The final temperature of the condensate then will be

$$T = \frac{(S \times 45) + (X + 500)1073}{S + X + 500} + 32 \text{ deg.} \quad (3)$$

where

S = Condensate from condenser, lb. per hour;
45 = B.t.u. in condensate above 32 deg. F. per lb.;
X = Bled steam, lb. per hour;
500 = Auxiliary exhaust, lb. per hour;
1073 = B.t.u. per lb. of bled steam and auxiliary exhaust.

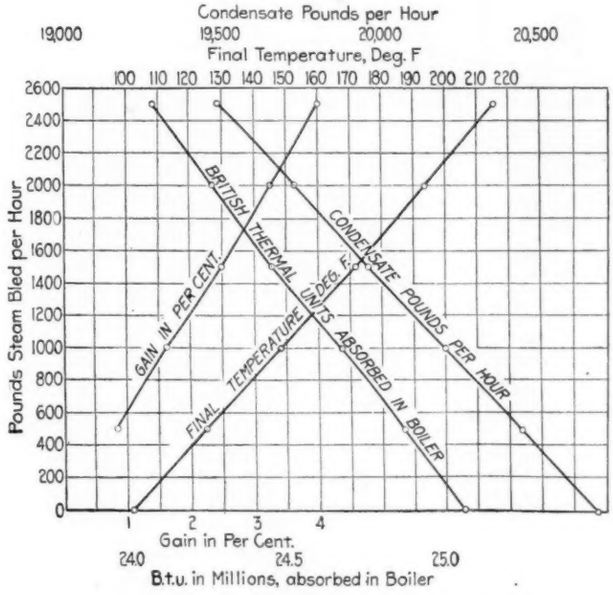


FIG. 2. DATA OF TABLE I PLOTTED

In all cases the total steam delivered to the unit is $(S + X + 500)$ lb. per hour and the heat that must be put into the boiler to generate this steam is

$$H = (S + X + 500) \times [1253 - (T - 32)] \quad (4)$$

where

S = Condensate per hour;
X = Steam bled per hour;
1253 = B.t.u. per pound of initial steam;
T = Temperature of feed water;
$(T - 32)$ = Heat of liquid in feed water, approx.

After all, H is the quantity of interest because it determines the amount of fuel which must be burned under the boilers. Using equations (1), (2), (3) and (4), Table I was computed by assuming successive values for X from zero to 2500 lb. per hour. The table is self-explanatory, the various quantities having been already defined.

With the pounds of steam bled per hour as ordinates, the corresponding variables in the table were plotted in Fig. 2. The temperature curve shows that when bleeding 2400 lb. of steam per hour, a feed-water temperature of 210 deg. F. is reached. Thus, since open heaters are being used, 2400 lb. is the limit to the steam it is possible to

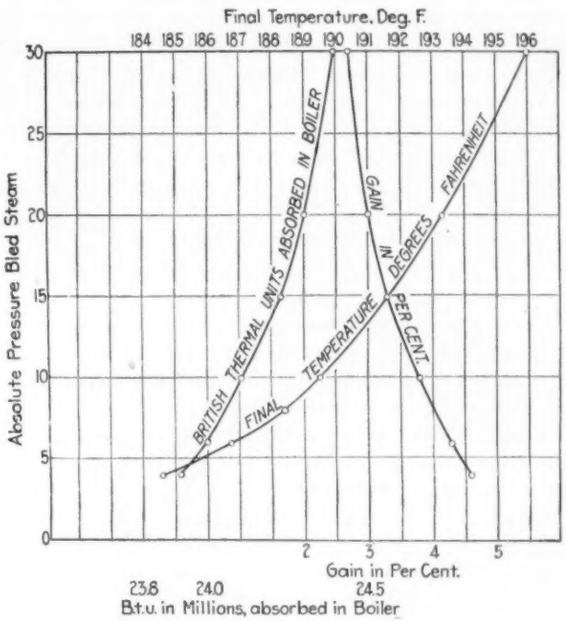


FIG. 3. GRAPH OF DATA IN TABLE II

bleed. The corresponding gain in economy is only 3.9 per cent. However, where more hot water than that for the unit itself can be used, the saving by bleeding steam becomes greater.

The foregoing discussion assumes an open feed-water heater, which is the practical heater for utilizing bled steam, as the latter is perfectly good feed water and should by all means mingle with the remaining condensate.

One point remains to be considered—the pressure at which the steam is bled. Table II has been computed on

TABLE I. ECONOMY OF BLEEDING STEAM TO HEAT FEED WATER

X Steam Bled, Lb. per Hr.	Hp_1 Horsepower from Bled Steam	$2,000 - Hp_1$ Horsepower from Condensate	S Condensate, Lb. per Hour	T Final Temp., Deg. F. $S+X+500$	H B.t.u. Absorbed in Boiler	Gain, per Cent.
0	0	2,000	20,670	101	25,065,000	.....
500	23	1,977	20,432	125	24,861,000	0.81
1,000	46	1,954	20,194	148	24,666,000	1.59
1,500	70	1,930	19,946	171	24,448,000	2.46
2,000	92	1,908	19,719	193	24,263,000	3.2
2,500	115	1,885	19,481	214	24,077,000	3.94

TABLE II. BLEEDING STEAM AT VARIOUS PRESSURES

Pressure Bled Steam, Lb. Abs.	Temp. Bled Steam, Deg. F.	Hp_1 Horsepower from Bled Steam	$2000 - Hp_1$ Horsepower from Condensate	S Condensate Lb. per Hour	T Deg. F.	H B.t.u Absorbed in Boiler	Gain, Per Cent.
30	250	73	1,927	19,900	196	24,394,000	2.7
20	228	88	1,912	19,760	193.3	24,301,000	3.0
15	213	98	1,902	19,660	191.6	24,230,000	3.3
10	193	111	1,889	19,500	189.5	24,101,000	3.8
8	183	118	1,882	19,400	188.4	24,015,000	4.2
6	170	127	1,873	19,350	186.7	23,998,000	4.3
4	153	139	1,861	19,230	184.6	23,912,000	4.6

a basis of bleeding 2000 lb. of steam per hour at pressures varying from 30 to 4 lb. abs. For pressures below atmospheric these values are purely theoretical, it being impossible to bleed steam at these pressures in the ordinary manner. Also for pressures below 9.5 lb. abs. the temperature corresponding to this pressure is lower than the computed resultant temperature, another impossible

condition, which shows that the water to be heated must be in excess of that used by the unit alone, in order to utilize the available heat in the bled steam at these low pressures.

Fig. 3 is a graph showing the relation between the pressure at which steam is bled and the corresponding values of T and H, T being the resultant temperature and H the heat to generate the steam required. The curves show clearly that the lower the pressure at which the steam is bled, the lower the final temperature but the greater the gain in economy.

The results obtained suggest an arrangement of heaters which has never, to the writer's knowledge, been applied to a steam turbine. No data are at hand to indicate the degree of practicability so far as steam-turbine practice is concerned, but the same idea has been used in connection with triple-expansion pumping engines, and a decided gain in economy claimed.[1]

It is proposed to employ two closed heaters of the multicoil type. One of these heaters is to be connected in parallel with a stage in the turbine at which the pressure is 10 lb. abs. It is possible to raise the feed-water temperature to 185 deg. in this heater. The other heater is to be connected in parallel with a stage in the turbine at which the pressure is 45 lb. abs. It is possible to further raise the temperature of the feed water in this heater to 270 deg. The condensate from each closed heater is trapped to the hotwell in the open heater, that from the high-pressure heater being passed through a coil in the hotwell before it is allowed to mingle with the water in the hotwell directly, in order to gradually cool it and prevent its flashing into steam at the reduced pressure.

The condensate is first pumped through the primary heater in the condenser and thence to the open heater supplied with auxiliary exhaust. From here the boiler-feed pumps send it through the closed heaters and into the boilers. Fig. 4 illustrates the arrangement.

The theoretical gain in economy due to such an arrangement can be computed as follows:

Let

C = Total steam supplied to the turbine, including that bled;

Y = Steam bled from the high-pressure stages;

Z = Steam bled from the low-pressure stages.

As before, the Rankine efficiency will be considered constant throughout the turbine and will be taken as 65 per cent. To simplify computations, the condensate from each heater will be considered as mingling directly with the water inside the respective coils, and it will be assumed that the final temperature of the water in the coils will be the same as that of the condensate in the heaters. The operating conditions will be assumed the same as before, namely:

Initial steam pressure, lb. abs	175
Initial superheat, deg. F	100
Pressure in first heater, lb. abs	45
Pressure in second heater, lb. abs	10
Exhaust pressure, lb. abs	0.5
Feed water in primary heater raised to, deg. F	77
Feed water in open heater and first closed heater raised to, deg. F	185
Feed water in second closed heater raised to, deg. F	270
Auxiliary exhaust steam, lb. per hour	500
Auxiliary exhaust steam pressure, lb. abs	17.7
Auxiliary exhaust steam, B.t.u. per lb	1,073

[1]See "Engineering News," July 18, 1912, p. 110.

The water that must be raised from 77 to 185 deg. is $C - Y - Z$. Then,

$$Z\,(1036 - 153) + 500\,(1073 - 153) = (C - Y - Z) \times (185 - 77) \quad (1)$$

$(1036 - 153)$ = B.t.u. available per pound of bled steam;

$(1073 - 153)$ = B.t.u. available per pound of auxiliary steam;

$(185 - 77)$ = B.t.u. per pound added to the feed water.

Again, the water that must be heated from 185 to 270 deg. is $(C + 500 - Y)$ pounds per hour. Therefore

$$Y\,(1139 - 238) = (C + 500 - Y) \times (270 - 185) \quad (2)$$

$(1139 - 238)$ = B.t.u. available per pound of bled steam;

$(270 - 185)$ = B.t.u. added per pound of feed water.

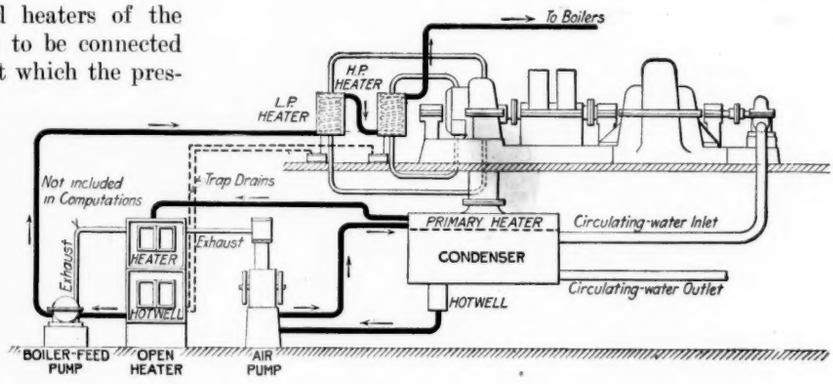


FIG. 4. BLEEDING THROUGH CLOSED HEATER FROM HIGH AND LOW-PRESSURE STAGES

The horsepower obtained from Z pounds of steam before being bled is

$$Hp_1 = \frac{Z \times 217 \times 0.65}{2546}$$

From Y pounds of steam,

$$Hp_2 = \frac{Y \times 114 \times 0.65}{2546}$$

From the steam passing entirely through the turbine,

$$Hp_3 = \frac{(C - Y - Z)379 \times 0.65}{2546}$$

Each of these horsepower equations is obtained by multiplying the heat per pound available for work, during adiabatic expansion between the pressure limits prescribed, by the number of pounds per hour and dividing the product by 2546, the quantity last named being the heat equivalent of one horsepower-hour. The quotient must then be multiplied by 0.65 the Rankine efficiency. Now the total horsepower is equal to $Hp_1 + Hp_2 + Hp_3$, or

$$2000 = \frac{Z \times 217 \times 0.65}{2546} + \frac{Y \times 114 \times 0.65}{2546} + \frac{(C - Y - Z)379 \times 0.65}{2546} \quad (3)$$

There are now three unknown quantities, C, Y and Z, and three equations that may be written as follows:

$$9.18Z + Y - C + 4259 = 0 \quad (1a)$$

$$11.61\,Y - C - 500 = 0 \quad (2a)$$

$$0.425\,Z + 0.696\,Y - C + 20{,}600 = 0 \quad (3a)$$

Solving these equations gives $C = 22{,}720$, $Y = 2000$ and $Z = 1791$ lb. per hour. The total steam supplied to the

unit per hour, including auxiliary steam, is 22,720 + 500 = 23,220 lb. The B.t.u. that must be absorbed by the boiler with a feed-water temperature of 270 deg. is $H = 23{,}220 \times (1253 - 238) = 23{,}568{,}300$. When bleeding no steam and heating with auxiliary exhaust it was found that $H = 25{,}065{,}000$ B.t.u. Hence the closed-heater arrangement shows a total gain in economy of $(25{,}065{,}000 - 23{,}568{,}300) \div 25{,}065{,}000 = 5.97$ per cent. Thus an additional saving of 2 per cent. is effected over the arrangement first discussed, employing open heaters only. With steam at 20c. per 1000 lb. and assuming constant operation, the additional saving per year would amount to

$$0.02 \times 21.170 \times 24 \times 365 \times 0.20 = \$740.95.$$

This saving is well worth considering, especially in view of the fact that the closed heaters would not cost more than about $1000 each.

It should be stated that with sufficient auxiliary steam available to raise the feed-water temperature above that obtainable in the low-pressure heater, the latter should be omitted. In such an event Z in the previous calculations would come out either negative or zero.

Practical Talks on Controllers—Lockout-Type Contactors*

SYNOPSIS—The operating principles of a lock-out-type magnet switch, for use on automatic direct-current motor controllers, are explained.

The broadening of the field of application of electric motors and automatic starters has led to their installation in industrial plants where the operators and even the superintendents are unfamiliar with the general principles and fundamentals of such apparatus. The fundamentals of this equipment are not difficult to understand and, if understood, greatly assist the electrician or workman in making adjustments and in the care of the equipment in general. At least such a description as proposed should convince the reader that there is nothing uncanny in some of the now peculiar results.

A large number of present-day starters use unit switches for contactors, commonly known as lockout or series switches, both meaning the same as to construction and principle of operation of the switch. The conditions operating the switch are not apparent to the eye, and hence to the uninitiated seem rather weird. The switch coil in this type of equipment is always connected in series in the main circuit, as distinguished from a switch having its coil connected in shunt or across the line.

The reason for connecting the lockout switch coil in series in the main circuit of starters is, as will be shown, that a fluctuating or varying current is necessary to the operation of the switch. As the voltage is normally constant and maintained so in all industrial plants, the

*The material in this article was contributed by W. H. Patterson, of the Westinghouse Electric and Manufacturing Co.

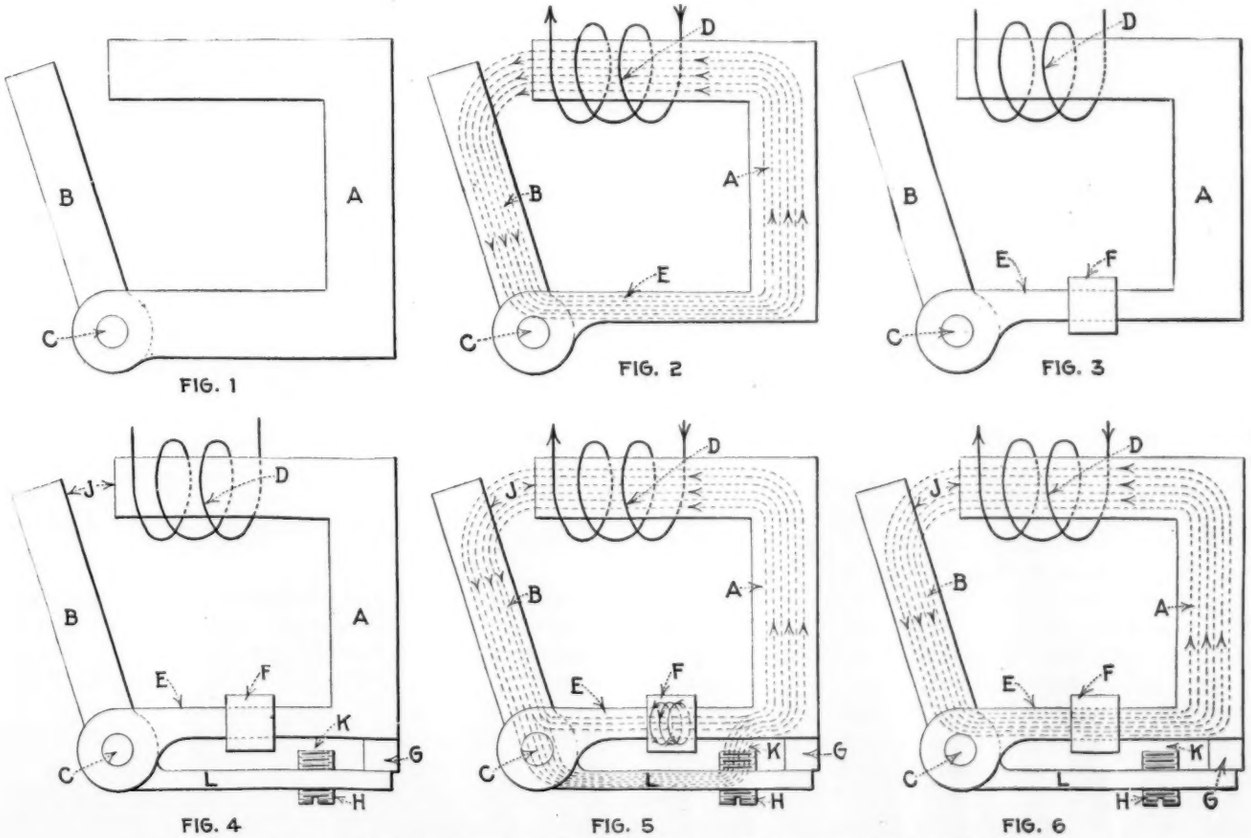


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6

FIGS. 1 TO 6. EXPLAINS THE OPERATION OF A LOCKOUT TYPE OF CONTACTOR

introduction of such a switch in the shunt circuit would be useless for the purpose intended. But its introduction in a series circuit where the current fluctuates, as in the starting of a motor, results in its holding open on certain values of current and closing on other current densities without the introduction of other auxiliary pieces of apparatus.

How it is that a switch can be made that will close at one time and remain open at another, either or both these results being obtained with the switch in circuit,

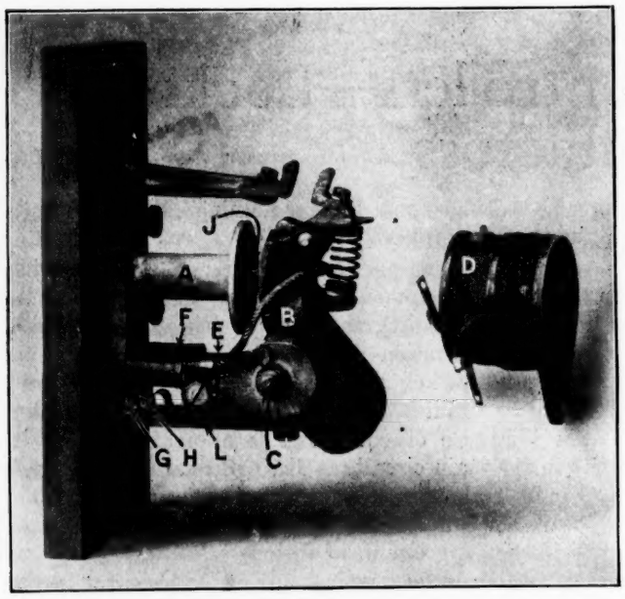


FIG. 7. LOCKOUT TYPE OF CONTACTOR DISMANTLED

when in general it is understood that on the closing of a circuit to the coil of such a switch the switch must close, is explained in the following:

In Fig. 1 is shown a simplified form of the magnetic circuit of an electromagnetic switch. *A* is a stationary iron frame; *B* is an iron armature free to move about the pin *C*, and it takes the position shown, owing to gravity. Fig. 2 is the same as Fig. 1, except that a coil *D* has been placed upon the upper leg of the stationary frame *A* and the section at *E* has been reduced. If an electric current is passed through this coil, a magnetic field will be set up, as indicated by the dotted lines. Reducing the section at *E* causes the magnetic field to be more dense in this section, so that it approaches saturation. The effect produced in Fig. 2 is similar to that of putting in a reduced diameter of water pipe in a system of piping.

If a copper loop *F* is placed around the core at *E*, as in Fig. 3, any change in the magnetic field will set up in the loop a current which will tend to oppose the change. For example, when the circuit to coil *D* is first closed, the current increases to a value determined by the resistance of the coil. As the current increases, the flux also increases through the iron core. This increase in flux through loop *F* will induce a current in it opposite to that in coil *D*, just as the current induced in the secondary of a transformer is opposite to that in the primary. The induced current in *F*, being opposite to that in *D*, will oppose the flux set up by *D*. Now there exists in Fig. 3 at *F* a condition that not only produces the effect of the small section of water pipe in a piping system, but also introduces the effect of an automatic valve, which opposes any change in the flow.

By extending the armature *B* as in Fig. 4, the lines of force can be bypassed around the loop *F* through *L*. In order that this bypass may be governed, a brass stop *G* (nonmagnetic) is placed on the casting *A* and a threaded iron plug *H* introduced (again considered as a valve). With this plug the distance *K* between the casting *A* and the armature tail or bell crank *L* can be varied without affecting the distance of gap *J*.

If a heavy current is caused to pass through coil *D*, as shown in Fig. 5, a heavy flux will be set up through the iron. But owing to the choking effect of loop *F* and also to the small cross-section of the iron at *E*, most of the lines of force are caused to take the by-path around *F*, through the plug *H*, back into the core *A*, as indicated.

The lines of force through *H* create a pull in the air gap *K*, which tends to hold the switch open, where the flux at *J* tends to close it. If the plug *H* is set near enough to the magnetic frame *A*, so that the pull at this point overcomes that at *J*, the armature will not close, and if this condition remains fixed, it would be impossible to make coil *D* close the armature. But when coil *D* is connected in series with the armature of a motor at starting, the conditions change. The current in the coil *D* dies down as the armature increases in speed, and the choking effect of the coil *F* gradually weakens because most of the lines of force take the path through *E*. This means that the opposing pull at *K* is no longer strong enough to overcome that at *J* and the armature closes. The resulting situation is shown in Fig. 6, which is practically the same as if the bell crank and coil *F* were not there.

As the pull depends on the gap and the number of lines in it, it will be seen that the relation between *K*

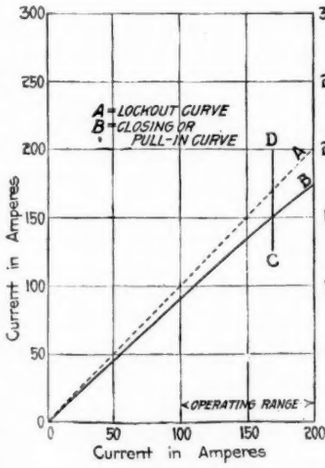


FIG. 8. LOCKOUT AND CLOSING CURVES

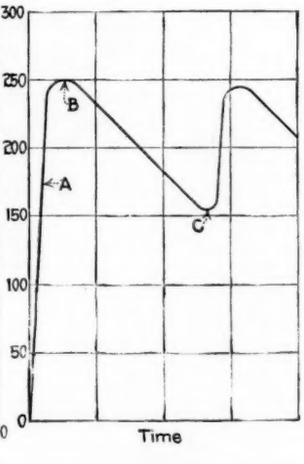


FIG. 9. OPERATING CURVE

and *J* may be adjusted by moving the screw *H*, and thus it can be predetermined at what current the switch will hold out and at what current it will pull in. This is the principle of the Westinghouse Electric and Manufacturing Co.'s lockout magnetic switch. The switch is shown dismantled in Fig. 7. The lettering on this figure has the same significance as that on Figs. 4, 5 and 6.

The curve of such a switch is shown in Fig. 8 and is known as the characteristic curve. It is obtained by varying the gap *K* by adjusting plug *H;* then observing

from a meter in the line at what current in amperes the switch will lock open and at what current it will close. For instance, if a switch is set (or the plug *H*) to close at 150 amp., the curve indicates that it will lock out at about 170 amp., but not below that value (see line *CD*, Fig. 8). In considering the starter, its principle of operation will be illustrated briefly by reference to Fig. 9. Assume that the switch is set to close at 150 amp., Fig. 9 indicates that the switch will remain open, showing a sharp ascending line on the curve. But Fig. 8 shows that to insure its lockout features, the peak of the curve, Fig. 9, must be 170 amp. or greater. It is evident from this that a switch having these characteristics will have its lockout and pull-in curve lines fairly close together. Returning to the consideration of Fig. 9, at the closing of the line switch the current almost instantaneously rises to a value limited only by the relation between the voltage and the resistance of the circuit. This can be predetermined since the voltage is known, and ohmic resistance can be inserted to a value that will satisfy Ohm's law for the current peak.

While the lockout switch is intended to close at the proper time, or when 150 amp. is reached, and cut its allotted part of the resistance out of the circuit, it will not do so under the conditions shown at *A*, Fig. 9, for the reason that the switch has been designed to have the magnetic conditions shown in Fig. 5, when the current in the coil *D* is rapidly rising. The switch therefore locks out as described in the reference to Fig. 5. But as the motor speeds up, the current falls off, as indicated by the line *BC*, Fig. 9, until the switch closes at about 150 amp. At the instant of closing the switch and cutting out a section of the resistance in the circuit, the current suddenly rises again and a similar cycle is repeated on other switches that may be on the controller.

[*The next article will point out some of the limitations of the lockout contactor and explain the operation of two types of controllers on which this type of switch is used.*]

Steam vs. Oil Engines for Small Light Plant

By L. H. Morrison

SYNOPSIS—How the type of engine was decided upon when it was necessary to replace an old one with one or two units. The choice was between three types of engines, and the article tells how a decision was arrived at, finally installing two 50-hp. semi-Diesel units as the most desirable.

Some time ago the operators of a small light plant found that they must install a new unit to replace the old Corliss engine and generator. The plant consisted of a 12x36-in. Corliss engine belted to a 75-kv.-a. single-phase alternator, a 72-in. by 16-ft. tubular boiler and the usual accessories. The boiler and accessories were in fair condition, but the engine and generator had outlived

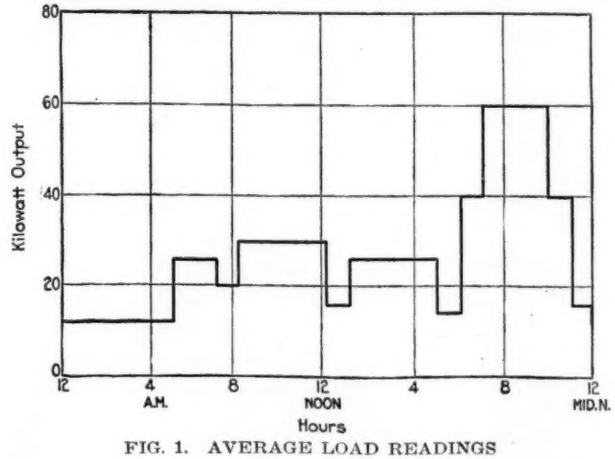


FIG. 1. AVERAGE LOAD READINGS

their usefulness, the engine especially being aged and worn.

As is usual in such cases, the owners were besieged from all sides by various steam-engine salesmen, and as time passed, instead of the field narrowing, it grew apace until it encompassed the high-compression and semi-Diesel oil engines. Finally all but three bids were eliminated; the first being on a 12x36-in. Corliss and 75-kv.-a. belted alternator; the second, on a 100-hp. high-compression oil engine with a 75-kv.-a. belted alternator; the third covered a 100-hp. semi-Diesel oil engine and a 75-kv.-a. belted alternator with an alternative offer on

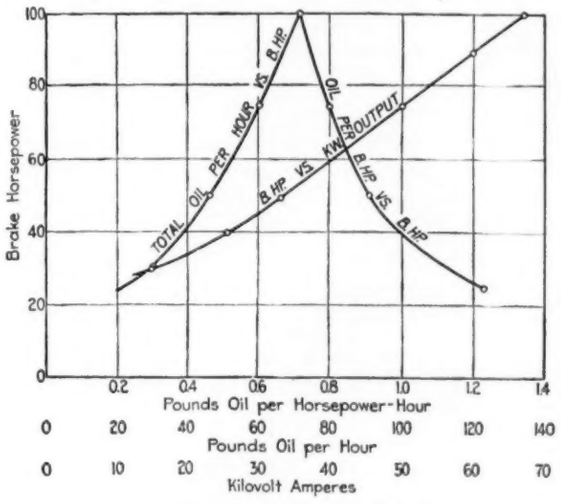


FIG. 2. SEMI-DIESEL OIL ENGINE CURVES

two 50-hp. semi-Diesels belted to two 37½-kv.-a. alternators.

The plant owners were in a quandary. They could not help recalling the faithfulness of the old steam plant, yet the fuel economy of the high-compression oil engine was seductive, while the semi-Diesel people laid stress on the fair fuel economy and low maintenance costs of their product.

In order to reach some logical conclusion, it was decided to lay out a load curve showing the average hourly load for a 24-hr. period. To do this, reference was had to the previous year's daily log sheets and two 24-hr. records for each month in the year were averaged, producing the load curve as shown in Fig. 1.

Taking up the semi-Diesel, the curve, brake horsepower vs. kilowatt output, was laid out by using the generator

efficiencies given in the specifications. Then the fuel-consumption curve, pounds of oil per brake horsepower-hour vs. brake horsepower, was developed. From this latter curve was laid out the curve, total oil per hour vs. brake horsepower.

Using the hourly kilowatt readings as shown on Fig. 1, it was easy to find the corresponding brake horsepower by using the curves in Fig. 2, and from this the total fuel oil used per hour. This is shown in Fig. 2. The total amount of fuel oil for the 24 hr. was 975 lb.

Since the guarantees on the 50-hp. semi-Diesels were the same as on the 100-hp. unit, it was not necessary to develop new curves. As an example, a 30-kw. load on the 50-hp. engine would be the same percentage of full load as a 60-kw. load on the 100-hp. engine. Consequently, the fuel per kilowatt would be the same as in the latter case, while the total fuel would be one-half the amount shown on the 100-hp. engine curve for 60 kw. The fuel used for 24 hr. amounted to 790 lb.

Fig. 3 shows the curves for the 100-hp. high-compression engine. The fuel consumption for 24 hr. amounted to 635 lb.

With the steam engine a slightly different procedure was necessary. The steam guarantees were given in terms of the indicated horsepower. The plant owners were informed that the mechanical efficiency at full load was 88 per cent. This then gives 105 brake horsepower when the engine develops its rated 120 indicated horsepower. A curve showing the steam per indicated horsepower vs. percentage of full load was first laid out. Then various values of indicated horsepower were taken, and from the steam consumption at these values the steam per brake horsepower was figured. As an example, the steam consumption at three-quarters full load was 26 lb. per indicated horsepower. Three-quarters load was 90 i.-hp., consequently the total steam used was $90 \times 26 = 2340$ lb.; but since the mechanical efficiency at full load was 88 per cent., it was evident that the friction load at any percentage was $^{12}/_{100}$ of 120, or 15 hp., which deducted from 90 i.-hp. leaves 75 b.-hp. consuming 2340 lb. of steam per hour.

In figuring the efficiency of the boiler it was estimated that, considering the load factor, a fair value would be 7 lb. of water evaporated per pound of coal as fired. Using these values, the coal per 24 hr. totaled 5720 lb. This estimate appeared correct, since it was about 10 per cent. less than the plant's past average, and the discrepancy could be easily accounted for in an old engine.

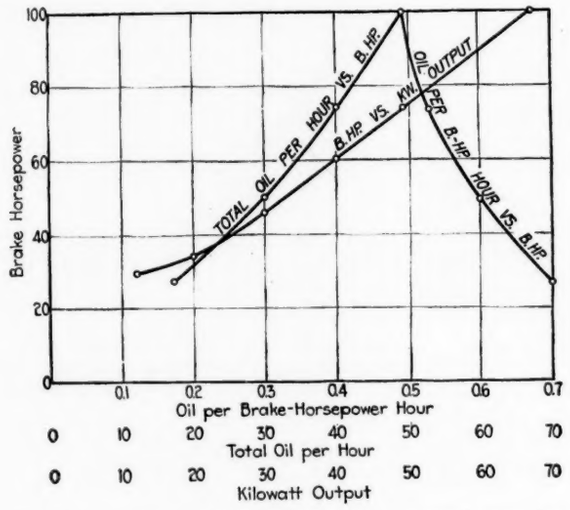

Brake Horsepower
TOTAL OIL PER HOUR VS. B.HP.
B.HP. VS. KW. OUTPUT
OIL PER B.-HP. HOUR VS. B.HP.
Oil per Brake-Horsepower Hour
Total Oil per Hour
Kilowatt Output

FIG. 3. HIGH COMPRESSION OIL ENGINE CURVES

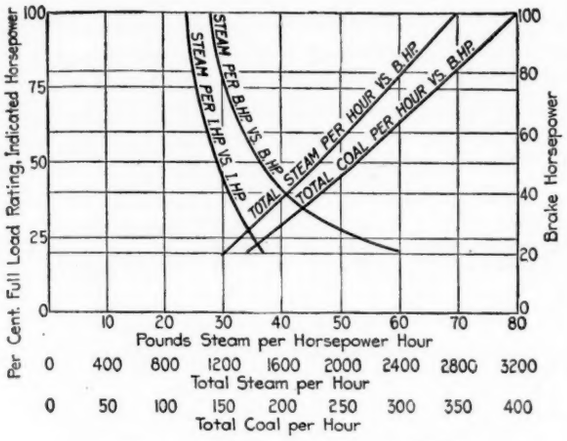

Per Cent. Full Load Rating, Indicated Horsepower
Brake Horsepower
STEAM PER B.HP. VS. B.HP.
STEAM PER I.HP. VS. I.HP.
TOTAL STEAM PER HOUR VS. B.HP.
TOTAL COAL PER HOUR VS. B.HP.
Pounds Steam per Horsepower Hour
Total Steam per Hour
Total Coal per Hour

FIG. 4. STEAM PLANT CURVES

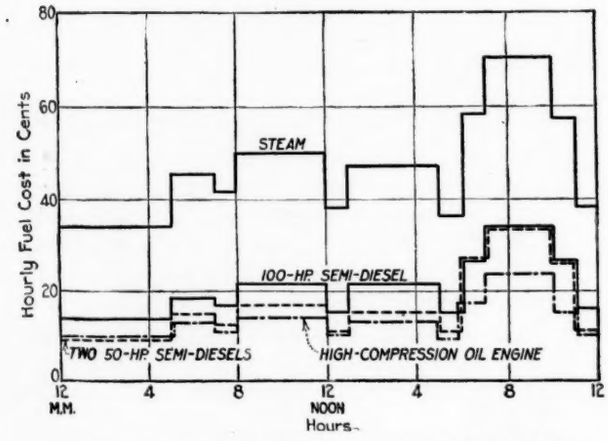


FIG. 5. HOURLY POWER COST, FUEL ONLY

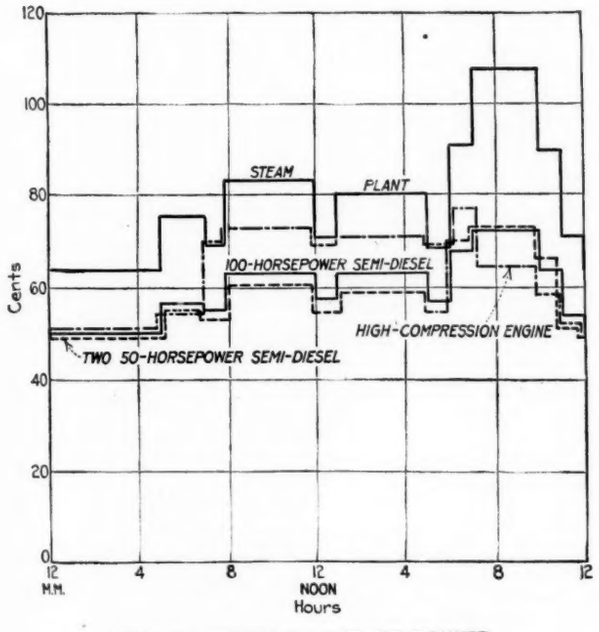


FIG. 6. HOURLY COST OF POWER

In figuring the overhead and labor charges, it was impossible to form an estimate that one could be positive was correct. However, the best authorities seem to charge a greater depreciation and maintenance against the oil engine than against the steam unit. The values adopted are shown in the table. In applying the fixed charges against the two 50-hp. units, it was argued that, since the engines were not in operation all the time, the depreciation and maintenance charges should be just one-half those charged against the 100-hp. set. However, in the calculations no allowance was made for this. As to the labor charge, this was known as applied to a steam plant; in respect to the oil engine a number of users of high-compression engines had, on inquiry, advised securing a high-grade man. As for the semi-Diesel, it appeared that one should have a better engineer than for the steam plant, yet apparently it was not current practice to use so high-priced attendance as with a high-compression installation.

In computing the various values in Fig. 6, the fixed charges were reduced to equal hourly amounts, while the wages of the day and night engineers were charged equally against the hours each was on duty.

On examining Figs. 5 and 6, it is noticeable that the high-compression engine shows a better fuel economy at all hours save the after-midnight run. On the strength of the fuel cost alone, this would appear to be the unit that should have been installed. However, a study of Fig. 6 shows that the two 50-hp. units possessed a lower total power cost save during the evening peak load, at which time it would have been eight cents per hour more than with the high-compression engine.

TOTAL OPERATION COST

	Steam Plant	100-Hp. High-Compression Engine	100-Hp. Semi-Diesel	Two 50-Hp. Semi-Diesel
Engine erected	$1,700.00	$6,300.00	$4,600.00	$4,850.00
Electrical equipment	1,600.00	1,600.00	1,600.00	1,800.00
Boilers, etc	1,350.00	.....	.....	.....
Extras	350.00	.....	.....	.....
Total cost	$5,000.00	$7,900.00	$6,200.00	$6,650.00
Interest	5 per cent.	5 per cent.	5 per cent.	5 per cent.
Taxes and insurance	2 per cent.	2 per cent.	2 per cent.	2 per cent.
Depreciation and maintenance	7 per cent.	12 per cent.	12 per cent.	12 per cent.
Total fixed charges	14 per cent.	19 per cent.	19 per cent.	19 per cent.
Total fixed charges	$700.00	$1,501.00	$1,178.00	$1,263.50
Yearly labor charges	1,680.00	2,400.00	1,920.00	1,920.00
Fuel cost (coal at $3.25, oil at $3.64)	3,394.50	1,168.87	1,696.77	1,462.75
Total yearly cost	$5,774.50	$5,069.87	$4,794.77	$4,646.25

Since the plant had about reached the maximum day load that it was possible to secure in the town, the two 50-hp. units were considered the most desirable.

Emergency Transformer Connections

By G. P. Roux*

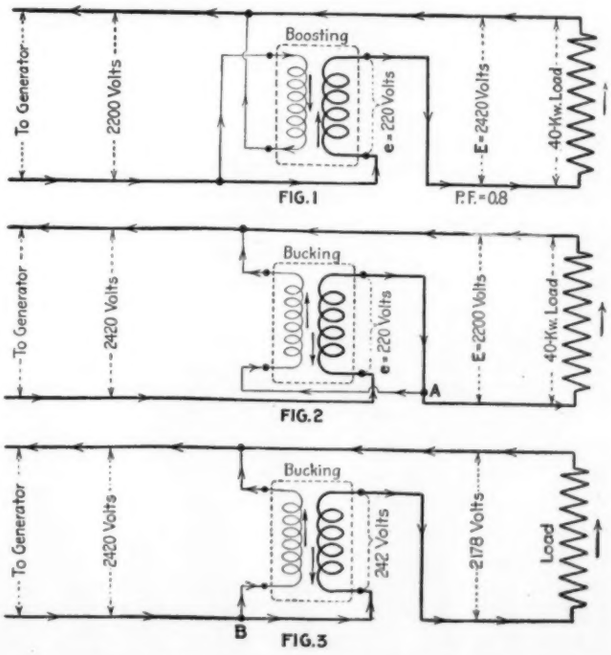
SYNOPSIS—Various transformer connections that can be made with the commercial type of equipment for compensating line voltages are given and explained.

The voltage drop caused on a feeder either on account of its length or the growth of its connected load may become excessive and inadequate to the service, and pending the installation of larger conductors or the adoption of some other remedy, the voltage must be increased at some convenient point. Likewise a power service may require a slightly higher voltage than the line voltage available, in order to insure a more efficient operation of the installation. Some other service features may require a 5, 10 or 20 per cent. higher voltage at a certain place, or inversely, a decrease in the value of the supply voltage may be required.

It is well known that in a transformer the primary current induces in the secondary another current theoretically 180 deg. apart; that is, in an opposite direction. These two currents can have their electromotive forces either added or subtracted according to the connections made. Thus if a transformer with a 2200-volt primary and 220-volt secondary is connected with its primary across a 2200-volt circuit, as represented in Fig. 1, with the primary connections reversed, the current at this instant may be considered flowing in the windings as shown by the arrows. If the secondary is now connected in series with one line, the voltage induced by the primary in the secondary will be in the same direction as the current flowing in the line, the voltage of which will be increased by 220 and will become 2200 + 220 = 2420 volts.

*Consulting engineer, Philadelphia, Penn.

Connecting a transformer, a duplicate of that in Fig. 1, on a 2420-volt circuit, but with the high-voltage winding connected as in Fig. 2, the secondary voltage will be in the opposite direction to that of the line voltage, which will be decreased by 220 volts; that is to say, become the same value as that ahead of the transformer in Fig. 1. Instead of connecting the primary of the transformer in Fig. 2 to the line at *A*, if it is connected at *B*, as in Fig.



FIGS. 1 TO 3. SIMPLE TRANSFORMER CONNECTIONS FOR INCREASING OR DECREASING THE LINE VOLTAGE

3, the primary electromotive force impressed on the transformer will be 2420 volts, and in its secondary 242, which deducted from the line voltage would give 2178 volts on the load side.

Various other styles of similar connections are shown in Figs. 4 to 9, where one transformer having a 2000- and 1000-volt primary and 200- and 100-volt secondary is used in each case. In all the diagrams the light lines represent the primary windings and the heavy ones the secondary, both windings being divided into halves. The arrowheads on all diagrams represent direction of current, the arrows on the transformers indicate direction of voltage. With transformers having two-coil primaries whose polarity is known, it is easy to trace the connections from the diagrams. When the polarity is not known, the transformers can be connected in the way thought best, and if after testing the line voltage it is found to be wrong, it is an easy matter to reverse the connections of one winding, preferably the primary, as it involves less work.

This system of voltage adjustment can be compared to a step-up transformer whose secondary windings are sectionalized, and instead of being concentrated at the point of transformation or the substation, are distributed along the line at points where a drop compensation is required.

The simplicity of this scheme is apparent and easily applicable to most cases met in practice and where a voltage

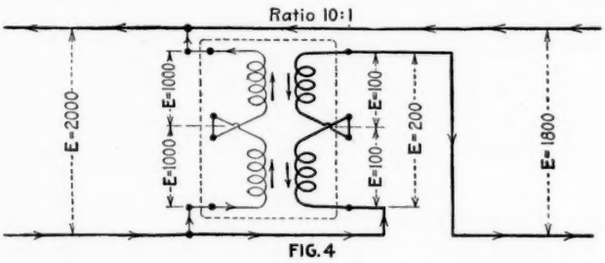


FIG. 4

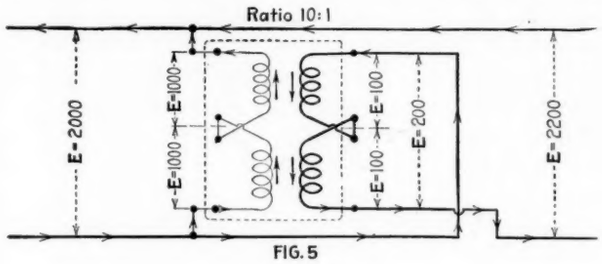


FIG. 5

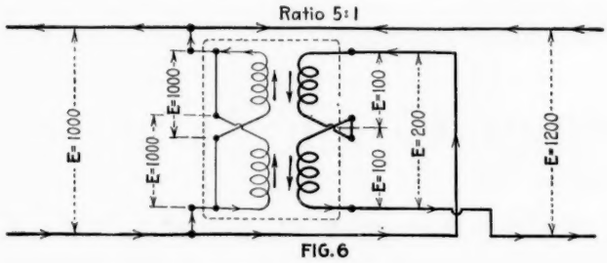


FIG. 6

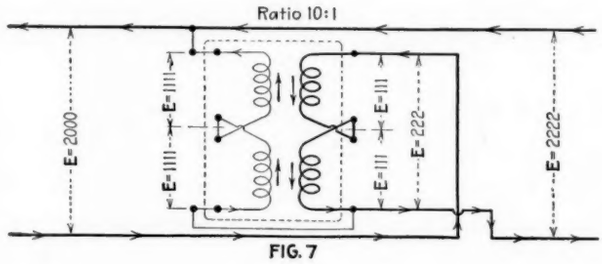


FIG. 7

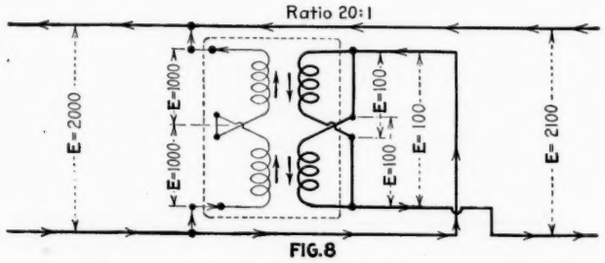


FIG. 8

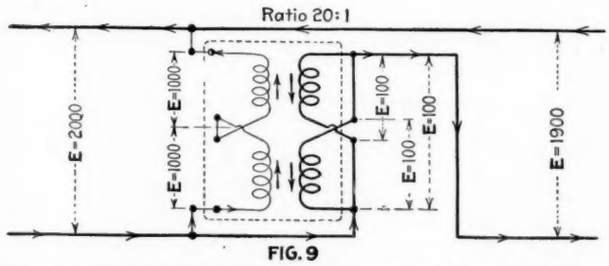


FIG. 9

FIGS. 4 TO 9. CONNECTIONS OF TRANSFORMERS, HAVING TWO-COIL PRIMARIES AND SECONDARIES, FOR DIFFERENT PERCENTAGE INCREASE OR DECREASE IN VOLTAGE

and secondaries, connections can be made for a wider range of voltage adjustment.

In Fig. 4 is shown a transformer connected to give 10 per cent. decrease in volts. Reversing the secondary connections as in Fig. 5 will give 10 per cent. increase. Fig. 6 shows the same transformer with the primary coils in multiple across a 1000-volt circuit and with the two secondary coils in series, thus boosting the line voltage 20 per cent. A 11 per cent. boost can be obtained by connecting the primary across the boosted line, as shown in Fig. 7. A 5 per cent. boost and buck is obtained with the connections shown in Figs. 8 and 9 respectively; these connections are the same as in Figs. 5 and 4, except that the secondary coils are connected in parallel.

The amount of voltage boost or buck depends entirely on the voltage rating of the secondary of the transformers, and the number of taps brought out from the windings. With properly selected transformers practically any fine voltage adjustment can be secured.

Special care must be taken to connect the transformers so as to secure the results in view. With transformers remedy must be applied. However, it is important not to abuse this remedy, because the introduction of additional induction apparatus on the line does not help the regulation of the system. The regulation is slightly worse, as well as the power factor on the line boosted. Higher voltages can be obtained by using more transformers with their secondaries connected in series and primaries in multiple. Reversing the primary or secondary connections will cause a voltage drop corresponding to the value of the secondary winding. The connections shown in the figures, although for a single-phase line, are equally applicable to a two-phase or three-phase system.

Should it become necessary later to improve the conditions of the feeder by adding more copper, or should it for some other reason be unnecessary to improve the line voltage, then the booster transformers can be removed and used somewhere else, as they are standard-distribution transformers.

The capacity of the booster compensating transformer required for this service must be determined from the kilovolt-ampere capacity of the feeder beyond the trans-

former. For example, in Fig. 1, assume that a 2200-volt single-phase line requires 10 per cent. voltage boost, which is to supply a 40-kw. load at 0.8 power factor. The kilovolt-ampere capacity of the compensating transformer may be determined by the formula,

$$kv.\text{-}a. = \frac{kw. \times 1000 \times e}{E \times P.F.}$$

where

$kv.\text{-}a.$ = Capacity of compensating transformer in kilovolt-amperes

$kw.$ = Connected load in kilowatts supplied through the secondary of the compensating transformer

e = Increase or decrease in line volts

E = Voltage on load side of compensating transformer

$P.F.$ = Power factor of the load.

The foregoing values are indicated on Fig. 1. In this problem $kv.\text{-}a. = \frac{40 \times 1000 \times 220}{2420 \times 0.8} = 4.55$. The nearest size standard transformer to this is 5 kv.-a., 2200 to 220 volts. In Fig. 2, the kilovolt-ampere capacity of the compensating transformer to supply 40 kw. at 0.8 power factor through its secondaries will be $kv.\text{-}a. = \frac{40 \times 1000 \times 220}{2200 \times 0.8} = 5$ kilovolt-amperes.

When connecting transformers as shown in the figures, no fuses should be used in either the primary or secondary connections, because if the primary fuses should blow with full-load current through the secondary winding, the flux in the core will attain a very high value, which in turn will induce an excessive potential in the primary winding, which may cause the insulation to break down, also the secondary will act as a choke coil in the line. The effect is similar to leaving a current transformer in circuit with the secondary winding open. The reason for not putting fuses in the secondary is that they do not offer any protection to the transformer.

Only sound transformers should be selected, having ample bushings for the secondary leads, which must be kept sufficiently spaced away from the case and from each other, both inside and outside of the case, inasmuch as they will be subjected to primary-voltage stresses.

Increasing the voltage to 2420, on the transformer windings in Fig. 1, might be objectionable were it not that all 2200-volt distribution transformers of modern design and construction are built so as to withstand a voltage of 10,000 volts while hot, between primary and secondary coils and the core combined, and the secondary coils to withstand a voltage test of 5000 volts between the coils and iron without injury. It is therefore safe to use these transformers for such emergency connections, protecting the primary and secondary coils with a lightning arrester when necessary.

Steam Engineer's License Examination

By H. F. Gauss

SYNOPSIS—A simple explanation of the causes of initial condensation in engine cylinders. Reduction of this loss by compounding the cylinders or by the use of the uniflow engine. Of the latter the principles of operation are fully covered.

In all the engines thus far considered steam is alternately admitted at the ends of the cylinder up to cutoff. It then expands down to the end of the stroke, after which it is swept out through the same end of the cylinder at which it enters. For this reason these engines are designated as "counterflow" engines, the term meaning that

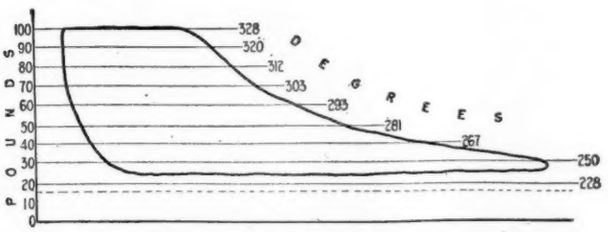


FIG. 1. DIAGRAM GIVING PRESSURES AND TEMPERATURES

the flow of steam in the cylinder during exhaust is opposite to that during admission.

An examination of the steam tables shows that the temperature of saturated steam at, say, 100 lb. pressure is 338 deg. When this steam is admitted to the cylinder of an engine and expands down to atmospheric pressure, its temperature drops to 212 deg., a cooling of 126 deg. This cooled steam then remains in contact with the cylinder walls throughout the entire exhaust stroke, being swept out through the same end of the cylinder at which it entered. It necessarily follows that the cylinder walls are cooled, and the longer the exhaust steam is in contact with them the cooler the walls become. Fresh high-

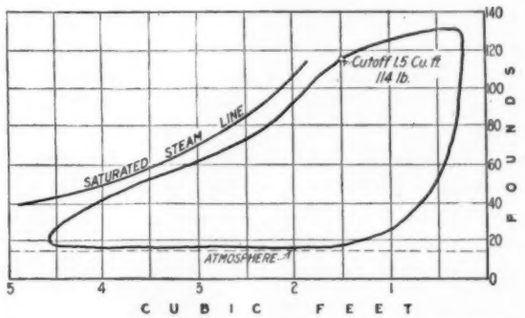


FIG. 2. DIAGRAM FROM A 250-KW. ENGINE

pressure steam entering the cylinder comes in contact with the comparatively cool cylinder walls, and part of it is immediately condensed. This is called initial condensation and is one of the main sources of loss in the steam engine.

Fig. 1 is an indicator diagram on which the temperature corresponding to the decreasing pressure during expansion is marked. The cooling action of the steam is thus made evident. An idea of the amount of condensation that takes place during admission can also be had from the indicator diagram. Fig. 2 is a diagram from a 250-kw. engine that was using 9067 lb. of steam per hour

and running at 175 r.p.m., or 350 strokes per minute. Hence the steam used per stroke was $\frac{9067}{60 \times 350} = 0.432$ lb. The engine cylinder is 20 × 24 in.; the area of the piston, 2.18 sq.ft.; piston displacement, 4.36 cu.ft.; clearance volume, 0.23 cu.ft.

The volume of steam actually present in the cylinder at any fraction of the stroke is the clearance volume plus the piston displacement up to the given fraction of the stroke. The length of the diagram represents the stroke to a scale determined by the reducing motion. Since the piston area is a constant quantity, the length of the diagram may also represent the piston displacement to some other scale. The piston displacement is the stroke in feet multiplied by the area of the piston in square feet, and the displacement up to any fraction of the stroke is the fraction of the stroke multiplied by the area in square feet, the result being in cubic feet.

The scale to which the length of the diagram represents the piston displacement is found by dividing the length of the diagram by the total displacement. Assuming that none of the steam condenses or is lost by leakage, the weight of steam present in the cylinder at cutoff is the weight trapped in the clearance volume plus that admitted up to cutoff. An examination of the diagram shows that the pressure at the end of compression is 90 lb. abs. From the steam tables it will be found that at 90 lb. pressure 1 cu.ft. of steam weighs 0.2044 lb. Hence the steam trapped in the clearance volume must weigh 0.23 × 0.2044 = 0.047 lb. Since the engine used 0.432 lb. of steam per stroke, it follows that the steam present at cutoff is 0.432 + 0.047 = 0.479 pound.

Again, the steam tables show that one pound of dry steam at 114 lb. abs., which is the pressure at cutoff, occupies 3.91 cu.ft. Hence 0.479 lb. should occupy 1.87 cu.ft.; but it actually occupies only 1.5 cu.ft., as the diagram shows. Hence some of it must have condensed, the amount being given by the difference between 1.87 and 1.5, or 0.37 cu.ft. The initial condensation is 0.37 ÷ 1.87 = 20 per cent. It is thus seen what an important item is initial condensation. Evidently the smaller the temperature range in any one cylinder the less the cooling during expansion and exhaust and the less the initial condensation. It is due to this fact that compound and triple-expansion engines have been developed.

Suppose we start with dry saturated steam at 100 lb. gage pressure and expand it down to a vacuum of 26 in. The initial temperature is 338 deg., and the final temperature is 125 deg. Such a range of temperature in a single cylinder of any of the engines thus far considered would be poor engineering to say the least. If this steam is expanded in two cylinders of a compound engine, the temperature range can be divided up and becomes approximately 106 deg. in each cylinder. The gain in economy thus obtained is well worth the additional cost entailed. For instance, a 250-kw. simple engine of certain make running noncondensing can produce a kilowatt-hour on 28 lb. of steam, whereas a compound engine of the same make and capacity running condensing can produce a kilowatt-hour on 19 lb. of steam. With steam at 20c. per 1000 lb. and the engine operating 300 ten-hour days per year, this saving in a year would amount to $1350, a saving certainly worth while. However, as will be shown later, other conditions may exist to make a simple engine more desirable. While the loss due to initial condensation can be greatly reduced by resorting to compound and triple-expansion engines, still it cannot be entirely eliminated and in any event is one of the main sources of low efficiency in steam-engine practice.

An engine has been successfully developed that decreases the time interval during which the cool exhaust steam is in contact with the cylinder walls, thus reducing the cylinder cooling, and also the initial condensation. This has been accomplished by placing the exhaust ports at the center of the cylinder and discharging the exhaust steam at the end of the working stroke. About 90 per cent. of the return stroke is a compression stroke instead of an exhaust stroke, and the time during which the cool exhaust steam is in contact with the cylinder walls is reduced to a minimum. The steam enters at the ends of the cylinder, flows to the middle and leaves through the central exhaust ports. It is for this reason that this type of engine has been named the "uniflow" in contradistinction to the older counterflow type. The piston itself is the exhaust valve and uncovers the exhaust ports at the end of its stroke. The exhaust-valve gear mechanism is thus eliminated.

There is one serious drawback, however, namely, the engine without some further provision for controlling the compression is essentially a condensing unit. With ordinary steam pressure, the compression starting at atmospheric pressure and continuing through 90 per cent. of the stroke would result in a final pressure considerably in excess of the initial steam pressure. Such a condition cannot be permitted. In the first place, as has already been pointed out, compression throughout such a range is accompanied by considerable condensation and part of the work is thus virtually thrown away. Second, there is an injurious shock at the beginning of the stroke, due to the sudden drop in pressure when the steam valves open, and the excessive pressures encountered are injurious to the bearings and connecting parts. These excessive compression pressures are prevented in three ways: (1) By employing excessively large clearance volumes; (2) by providing relief, or shifting, valves; (3) by employing a set of auxiliary or secondary exhaust valves which are located in the cylinder walls at about the point where compression should begin in an ordinary counterflow engine of the same speed.

The first of these methods is undesirable, as excessive clearance is detrimental to good economy and tends largely to counteract the gain due to the uniflow principle. The second method necessitates the use of valves located in places hard to get at and repair in case of necessity.

The third method, that used by the manufacturers of a well-known uniflow engine, is thoroughly practical.

Efficiency of Propulsive Machinery in Naval Engineering—Reports made in 1912 on the relative performance of turbine-engined and reciprocating-engined naval vessels indicated the superiority of the latter for battleship propulsion. Trials of vessels constructed later, however, showed that the real cause of the poor showing of the former lay in the faulty design of turbines and propellers. So far as economy at different speeds is concerned, it is shown that there is but slight choice between the different types when they have the proper propeller efficiency. At very low powers the reciprocating engine is about as economical as the geared cruising turbine, and both of these are more economical than the directly connected cruising turbines; and it is evident that matters other than economical performance should decide the question of type of prime mover. The geared turbine and electric drive are recent innovations which show decided economy and a material saving in weight over directly connected units.

Brushes Chipped and Heated

By E. C. Parham

The heating of generator or motor brushes may be due to any or all of several conditions: Excessive friction, sparking, overload, quality of brushes, high mica, etc. If the heating is due to excessive friction between brushes and commutator, the brushes and holders will heat even when the machine is operated at normal speed and without field excitation. When easing the brush-spring pressure does not relieve the conditions, the trouble is likely to be due to the composition of the brushes. If there is no appreciable heating when the machine is operated with excitation removed, the other possible causes of heating must be investigated.

An engineer reported that the brushes of one of the exciters were chipping. By the time that an inspector got on the job, the chipping had been stopped and the complaint changed to one of heating. The engineer stated that the brushes would get hot even with the field circuit open.

The exciter commutator had just been turned down, but the brush-holders had not been moved in radially to suit the reduced commutator diameter, and as the mica was slotted, the rough surface together with the excessive clearance caused the brushes to chatter badly and chip. New brushes were then installed and the holders turned on the studs until the brush-holder clearance was correct. The turning of the holders on the studs pulled the brushes back from neutral and tended to make the toes stick into the slots between bars. This was corrected by shifting the whole yoke forward and by sandpapering the brushes to a new fit. After the brushes were properly adjusted, the machine ran absolutely sparkless at all loads, but the brushes and holders heated too much even at no-load and without excitation. Thinking that the change in the angle of the holders might have something to do with the heating, they were turned to their original angle, the brushes sandpapered to a new fit, the holder shifted to the original neutral mark and the clearance taken up by loosening the stud nuts and shoving all studs in toward the commutator; but there was no noticeable improvement. A pair of discarded brushes of the kind originally shipped with the machine was then installed in one pair of holders. The effect was satisfactory; heating entirely ceased as far as those two holders were concerned. Discarded brushes of the original kind were then placed in all holders, and although they were short, they gave comparatively good results until new ones could be obtained. The heating was caused by the poor quality of the new brushes.

A Quick-Setting Rust Joint Cement—One part by weight of sal ammoniac, two parts of flower of sulphur and 80 parts of iron filings made into a paste with water.

Technical Propriety in Engineering Societies—However laudable may be the desire to maintain the proceedings of our great engineering societies on a high plane of technical propriety, it cannot be denied, even though it has been ignored in the past, that the engineer is everywhere confronted in his work by the all-important question of costs and balance sheets, and himself is usually under the necessity of earning a livelihood by his profession. Hence, an ostrich-like pretense that trade and finance have no concern for him is mere affectation, and we are glad to see that both the civil and electrical engineers have begun, somewhat shyly it may be, but effectively, to recognize their responsibilities in this connection.—"The Electrical Review," London.

Ventilating a Public Dining Room

By Albert L. Baum

A problem involving the ventilation of a large dining room and kitchen may be of interest to "the man on the job." Although simple enough, it included certain little kinks that may be useful to others.

The original means of "ventilation" had been open windows, front and back, and these could not be opened in cold weather without discomfort to those seated near them; and with the windows closed and some 400 people dining, dancing and smoking, the air would soon become

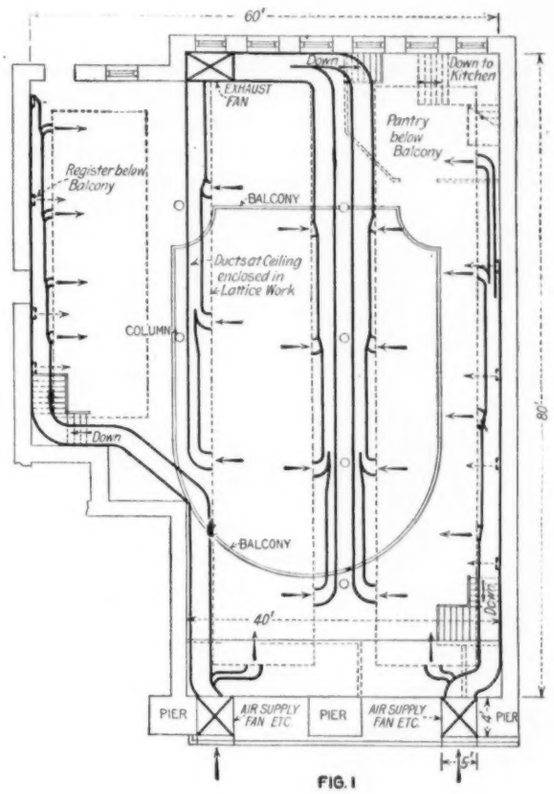


FIG. 1

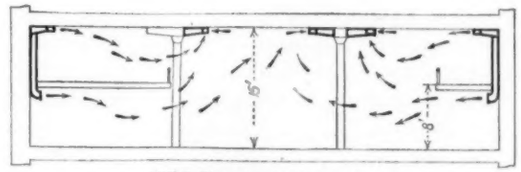


FIG. 2 Showing Air Currents

FIGS. 1 AND 2. FAN AND DUCT SYSTEM OF VENTILATION
Fig. 1 is the general layout of ducts. Fig. 2 indicates the course of the air currents

thick and stuffy. To make matters worse, there was the odor of cooking and the heat from the kitchen, so that something had to be done. There were three principal things to be accomplished—drawing out the smoke and heat from the ceiling, bringing in fresh air for breathing and keeping out the kitchen smells. The logical thing to do, then, is to draw off the hot air and smoke at the ceiling and to introduce well-distributed fresh air, and the success of the installation is in the matter of distribution—of getting rid of bad air and bringing in fresh air at numerous points so as to avoid unpleasant drafts. The duct layout is shown in Fig. 1, the exhaust

being taken from the ceiling along the length at the center of the room and the fresh air supply introduced just above the headroom along both sides of the room, above and below the balcony. The course of the air currents is shown in Fig. 2.

The most difficult problem on this job was the selection of suitable locations for the air inlets, tempering stacks and fans. The first intention was to put all the air-supply apparatus in the basement, running the branch flues up into the dining room; but when the basement was examined, it was found to be already crowded with promiscuous equipment, refrigerating machinery, gas, water and refrigerating piping and electrical conduits; in fact, such a maze of stuff that the idea of putting the fans and ducts there was abandoned. The entire front of the building was glass except the space taken up by the stone piers, which were very deep, carrying the upper stories. This construction resulted in out-of-the-way corners on the balcony, otherwise wasted, in which compact air-supply apparatus could be placed. One pane of glass in each of the two front corners was removed, and the openings were fitted with louvers and used for air inlets, as they were high enough above the street level to avoid drawing in a great deal of dust.

The inlet air was tempered by means of Vento stacks, laid horizontally to best utilize the space. The sections chosen were one row of narrow width and one row of regular width to apply a varying amount of heat to the incoming air to suit weather conditions. The stacks and blowers were carried by a steel supporting frame of liberal area, to distribute the load.

Multiblade fans with motors mounted directly on the fan housing were selected, since space was an important factor. Each air-supply rig, complete for warming and blowing 3000 cu.ft. per min., takes up a space of only 4 x 5 ft. and 7 ft. high, inclosed in a sheet-iron casing provided with doors for access to the motors and air inlets, covered and painted, so that from the room the inclosures look like parts of the heavy masonry piers.

The exhaust fan is of the same type as the blowers and was set on the balcony level but in the rear, and its discharge was carried out through the top of a window and turned upward. This elbow had an open screened top and was provided with a gutter near the wall to drain out rain falling into the opening.

The system was put into operation with the room crowded to its capacity, and the improvement over former conditions was remarkable, for instead of depending on the few windows at the front and rear for ventilation, involving cold drafts on those seated near them while affording no relief to those in the center of the room, the whole room was well ventilated yet free from drafts which, after all, is the real test of the success of a ventilating system.

Visits of Inspector Brown—XXVIII

By J. E. Terman

SYNOPSIS—This time the Chief gets at diagraming the Code formula for the spacing of stay-bolts, also according to the Massachusetts formula.

"Well, here I am again, Chief," said Brown, as he walked into the Chief's office, "ready to follow up the problem of diagraming the Code formula for the spacing of stay-bolts."

"I am glad to know that you are so much interested, Brown," said the Chief. "You will remember that the last time we were talking about this subject, I showed you that the Code formula for the spacing of stay-bolts could be represented by straight lines without the use of logarithms or reciprocals. You can see from the formula,

$$P = C\frac{t^2}{p^2}$$

where

P = The maximum allowable working pressure in pounds per square inch;
p = The maximum pitch for stay-bolts;
C = A constant, the volume of which is changed for certain differences in plate thicknesses;
t = Plate thickness.

that if logarithms are used, the formula,

$$\log P = \log C + 2 \log t - 2 \log p \qquad (1)$$

will be true the same as the original formula. You can also see that formula (1) will be a straight line, where C and t or C and p are considered to be constant in value. If C and t are considered constants, the representation of the values given by the Code formula by using logarithms will be like this," said the Chief, indicating Fig. 1. "I have made this diagram merely to show how such a diagram would appear, for neither this method nor the one that we discussed the last time is the best for all-around use.

"One of the objections to making a diagram of the Code formula for the spacing of stay-bolts by the method we talked about last time, was that there was a break

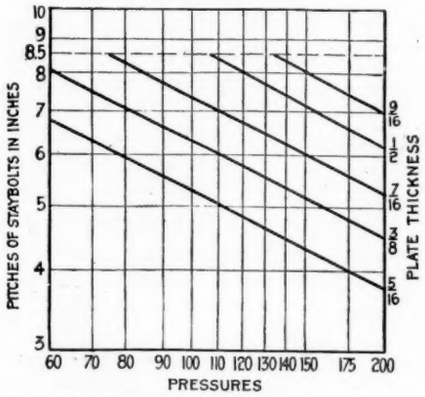


FIG. 1. VALUES BY CODE FOR MULES, USING LOGARITHMS

in the diagram due to the two different values necessarily applied to the constant C." See Fig. 2, Visit 27.

"If, instead of considering C and P constant as we did in that case, C and t^2 should be considered to have constant values, the break in the diagram would be avoided. The formula for the spacing of stay-bolts would then become $P = \left(\frac{1}{p^2}\right) Ct^2$, and since the expression in the brackets is to be considered a variable, this for-

mula may be represented by straight lines, by laying off the values of p, as reciprocals of squares of that variable rather than direct values.

"Since plate thicknesses are generally specified in sixteenths or thirty-seconds of an inch, if the lines representing the values of t are arranged to represent steps by thirty-seconds, the diagram should serve all practical purposes. Also, if the lines representing the values of P are arranged to represent variations in pressure by 5-lb. increments, the variations in this factor should be close enough to serve our purpose. Again, if the variation in pitch indicated on the diagram is in increments of $\frac{1}{4}$ in., the resulting diagram should be entirely serviceable. Following out these ideas in representing the Code formula as I have just written it, you would have a diagram about like this," showing Fig. 2. "I will not make a working diagram with the divisions as fine as we have discussed, because after this discussion of the principles involved, you will be more certain that you understand the subject if you make the diagram yourself.

"Suppose," continued the Chief, "that it had been desired to get the values for the maximum spacing of stay-bolts as given by the Code formula and by the Massachusetts formula on the same diagram, so that a ready comparison of the two rules might be made; how would you go about solving that problem?"

"Gee, Chief, that's just the kind of a diagram I want! Casey's foreman always has up the problem of how to build a Code boiler for a derrick that will also comply with the Massachusetts rules, and if I can get him a diagram of the kind you mention, he can tell at a glance what pitch to select so as to come within the requirements of both sets of rules. I don't know whether I can solve the problem or not, Chief," continued Brown, "but since you have given three methods by which the Code formula may be diagramed by means of straight lines, I presume that at least one of these should fit the case of the Massachusetts formula."

"Here is the Massachusetts formula for the pitch of stay-bolts, Brown: $P = \frac{C(t+1)^2}{S-6}$. See what you can do with it," said the Chief. "You will remember that in this formula P represents the working pressure the same as in the Code formula and C has a constant value of 66, t represents the plate thickness in sixteenths of an inch, the same as in the Code formula, and S represents the pitch of stay-bolts, or the same factor as represented by p in the Code formula. Therefore, if the Massachusetts formula and the Code formula should be written with the same letters to represent the same values in each case, for plate thicknesses of $\frac{7}{16}$ in. and under the Code formula would be

$$P = \frac{112t^2}{p^2} \qquad (2)$$

and the Massachusetts formula would be

$$P = \frac{66(t+1)^2}{p^2 - 6} \qquad (3)$$

I am only telling you this much, Brown, to give you a fair start on the problem of making a diagram with straight lines that will fit both formulas."

"I suppose that I would have thought that out after a time, Chief, but I am glad you gave me the lift," said Brown. "Since I know all about diagraming the Code formula, I will start on the Massachusetts formula first. By using logarithms, the Massachusetts formula would be, $log\ P = log\ 66 + 2\ log(t+1) - log(p^2 - 6)$." After considerable study of this formula, Brown said: "If a separate line were used to represent each value of p, I think the algebraic sum of $log\ 66$ and $log(p^2 - 6)$ could be used in the formula for each separate line, and then the formula would be in the form of $y = ax + b$ where 2 would represent the value of a."

"Yes, Brown, that is so, but the difficulty is that instead of having the variable t to deal with you would have $(t + 1)$, which would mean that the line representing $\frac{3}{8}$ in., or $\frac{6}{16}$ on your logarithmic scale, would in reality represent $\frac{5}{16}$ for the plate thickness. This would not be a difficulty where the Massachusetts formula alone is concerned if the figures on the scale for thicknesses were properly arranged, but if the Code formula were required to be plotted on the same sheet, then each vertical line would have to represent two values of t; thus one line would be marked $\frac{3}{8}$ for the Code and $\frac{5}{16}$ for the Massachusetts formula, another $\frac{7}{16}$ for the Code and $\frac{3}{8}$ for the Massachusetts formula and so on for all values of t. There would also be a break in the diagram for

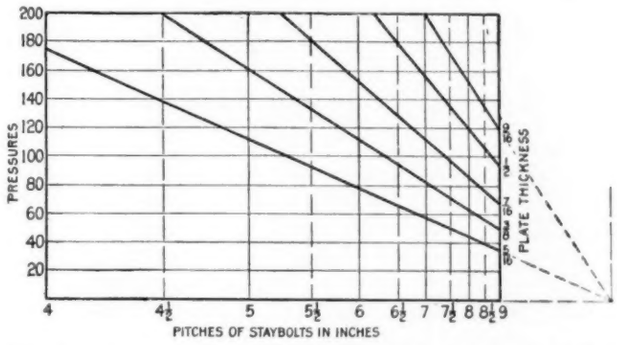


FIG. 2. DIAGRAM FOR STAY-BOLT SPACING ACCORDING TO THE CODE

the Code values, at the $\frac{7}{16}$-in. plate thickness line. You can easily see, Brown, that this kind of a diagram would not permit a ready comparison between the values given by the two formulas under consideration."

"Well, Chief, since you have knocked that plan in the head, I don't see where to start," said Brown. "I can see that there is no way to arrange the Massachusetts formula so that the square root of each side may be extracted, as you did with the Code formula. I can also see that the values of t^2 cannot be used as you have just described in diagraming the Code formula, for if t is not considered a constant and the square root of $(t + 1)^2$ is not suitable to work with, the formula will certainly not be a straight line."

"That is perfectly true, Brown, but still the problem I have given you, to represent both formulas on one diagram by means of straight lines and arranged so that the values as given by the two will be comparable, can be solved," said the Chief.

"The method is really simple. The Massachusetts formula is the most difficult to handle, so the thing to do is to get a method that will suit that formula and then see if it can be applied to the Code formula. I will agree with you, Brown, that t must be considered constant; that is, there must be a separate line to represent each value of t. If the factors are transposed in formula

(3), it can be written thus:

$$p^2 - 6 = \frac{66(t+1)^2}{P}$$

or what is the same thing,

$$p^2 = \frac{66(t+1)^2}{P} + 6 \qquad (4)$$

You can see that if t in formula (4) has a constant value and the values representing p are laid off as squares and those representing P are laid off as reciprocals, then this formula could be represented by straight lines, for it would be of the form of $y = ax \pm b$. Examining the Code formula (2), it is seen that it may be written

$$p^2 = \frac{112t^2}{P} \qquad (5)$$

and likewise if the values of p are laid off as squares and the values of P as reciprocals, this formula may be represented by straight lines, for it will be of the form of $y = ax$. All the lines on such a diagram representing the Code-formula values will pass through the intersection of the x and y axes; those representing the Massachusetts formula will pass through a point representing

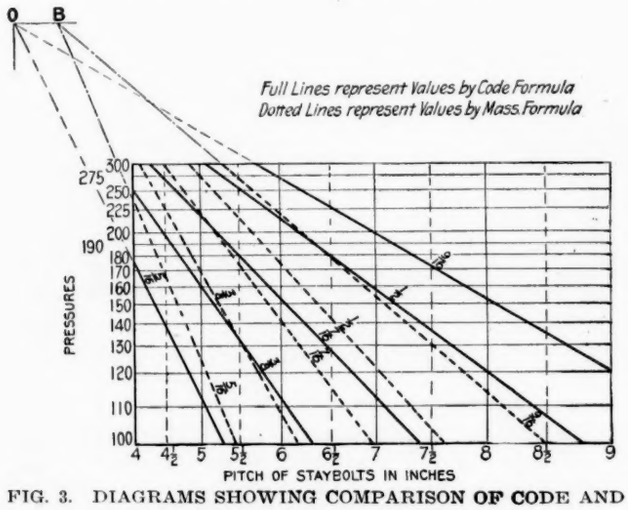


FIG. 3. DIAGRAMS SHOWING COMPARISON OF CODE AND MASSACHUSETTS FORMULAS

a value of 6, to the right of the intersection of the x and y axes.

"Here is such a diagram," said the Chief, showing Fig. 3, "and while it is not complete enough to serve your purpose, you can easily see that a larger diagram made on the same plan will afford an excellent means for comparing the values for stay-bolt spacing as given by the Code formula and the Massachusetts formula."

"Say, Chief," said Brown, "you said that the lines for the Massachusetts formula would pass through a point representing 6 to the right of the y axis and the distance OB in Fig. 3, would seem to be the one you referred to, but it is not anywhere near the vertical line representing 6 in. as a pitch for the stay-bolts."

"You are now speaking without giving consideration to the subject," said the Chief, "for if you had given this question a moment's thought you would know that the distance from the y axis to the line representing a pitch of 6 in. is actually laid off to represent a value of 36, or the square of 6. If you will take the distance from the y axis to the 6-in. pitch line as 36, you will see that the distance from O to B will be $\frac{1}{6}$ of that distance; that is, 6 to the same scale."

"Say no more, Chief; I am getting worse all the time, but this experience in diagraming the Code formula and the Massachusetts formula has taught me a lesson. I can see that a problem of this kind should never be given up, for there seems to be no end to the number of combinations that may be used to accomplish the desired purpose. I will make up a working diagram like Fig. 3, just as soon as I get home, and it should certainly make me solid with Casey's foreman for a while, anyway."

"Come in again, Brown, when you have the time and we will try and get some other illustrations of the advantages to be gained by diagraming formulas."

STUDY IN CAUSE AND EFFECT

CAUSE

EFFECT

Editorials

Idle Isolated Plants Can Help Solve the Power Shortage

To carry on the great industries for equipping our armies and supplying those of our allies in Europe, we require four very essential elements. Raw materials; machinery; labor to operate the machinery to convert the raw materials into finished products of every kind to supply the prodigious war machine; and power, the most important of the four, to drive the machinery. This last item is one that largely interests the central stations.

In normal times the central stations have in general found no difficulty in taking care of any power demands that they have been called upon to supply, but in these days of intensified industrial activity, when large enterprises spring up almost overnight, the central-station industries are finding themselves hard pressed to supply the needs of their localities—not only on account of the rapidity with which the loads have increased, but also because the electrical manufacturers have been unable to make short-time deliveries, they too having been overwhelmed with demands and having found themselves handicapped in obtaining raw materials.

All over this country there are hundreds of isolated plants that have been shut down to take on central-station service. Many of these could be put back into service in a very short period, releasing large blocks of power which the central stations might use to supply new industries. Here is an opportunity for the public utilities to perform a patriotic service by seeing to it that if their own plants have insufficient capacity to supply the power needs in their territory, every idle isolated plant that can be utilized is put into service. Many of these plants can be operated in parallel with the central station's system, if necessary by the central stations themselves, and have capacity enough to supply the needs of the industry to which they belong and, in addition, a reserve that may be used to assist in supplying other enterprises. By doing this the central stations will be able not only to meet the power demands of their districts, but also to allow the power-equipment manufacturers an extension of time on their deliveries, which will permit the diversion of an additional amount of raw materal, machinery and labor to supply other important needs of the nation.

⁂

Public Confidence Is Warranted

Speaking from personal knowledge of conditions on the other side, Pomeroy Burton, manager of the London *Daily Mail*, recently said before the Merchants' Association of New York that the main reason for the inability of the people of this country to grasp the true significance of the war today is the policy of suppression of news which has prevailed in the principal entente countries since the first shot was fired. "This close censorship," he said, "has cost them dearly and has kept the spirit and meaning of the war from entering the minds of this and other countries remote from the conflict."

This is the frank opinion of an American who has spent the last ten years in England and who has had exceptional opportunity for observation. But it is not alone the opinion of one individual; it is confirmed by most well-informed Englishmen. In fact it is generally conceded that had the English government taken the public into its confidence at the start, many unnecessary sacrifices might have been avoided. Now they are freely laying before us the lessons from their early mistakes so that we may avoid the pitfalls.

It has been truly said that "no democracy was ever effective in war without the full understanding and backing of the masses." Every person in the United States today has an individual responsibility in this war, but he must be made to feel the full force of that responsibility by knowing the facts and being permitted to cooperate. The cost in lives and money will then be met ungrudgingly.

With every form of government similar to our own, lost motion is inevitable in coördinating departmental work and getting the machinery into operation. Meanwhile the tendency is to surround every move with an air of secrecy; not because of any real intent to keep the public in the dark, but rather through lack of authority to give anything out. However, the authorities at Washington have done well to appoint as official censor a man well known in the newspaper world and one who is likely to recognize the value of a broad-gage policy in disseminating information, save, of course, that of military character such as might be of value to the enemy.

The response of the daily, trade and technical press to the needs of the present emergency have been almost instantaneous; they have shown an eagerness to meet the Government more than half-way and are anxious to go still further in any work that will serve to bring home to the people the full significance of the present situation. It remains with Washington to say how far they shall be permitted to serve in this work.

⁂

Bleeding Turbines

The most efficient cycle upon which a heat engine can be worked is that of Carnot. In this cycle all the heat must be put into the working medium at the maximum temperature, as (in the steam engine) expanding the water at the boiling point into steam. This is expansion at constant temperature, or isothermal expansion. The temperature is then lowered by expansion, during which no heat must escape except as it is converted into work and no heat must be added to the medium, as this would be contrary to the first requirement that all the heat must be received at the maximum temperature. This is adiabatic expansion. When the temperature reaches the lower level, the medium is contracted by cooling (in the steam engine by the condenser). This all takes place, theoretically at least, at the lower temperature level and is isothermal compression. If the cooling is stopped at a certain point in the return stroke and the

mixture of steam and condensate compresses during the rest of the stroke, it will be restored to water at the initial pressure and temperature.

The Carnot cycle, of course, represents an ideal and is not attainable in practice; nor can it be applied directly to the steam turbine. There is no compression in the case of the turbine to correspond with the fourth operation in this cycle; but if the temperature of the condensate be raised to that of the boiler by the expenditure of turbine steam, then the analogy is complete. This cannot well be accomplished in a single operation, but can be approximated by steps. Such is the plan proposed by Mr. Gauss in his article on "Bleeding Turbines To Heat Feed Water."

By heating the condensate first in a primary heater in the condenser, then in an open heater by exhaust from the auxiliaries, and finally in two closed heaters supplied with steam bled from low and intermediate stages of the turbines, a theoretical gain of nearly six per cent. is obtained.

The principle is not new; it has been used to advantage in large reciprocating engines, notably the Wildwood pumping engine at Pittsburgh as far back as 1899. Tests of this installation conclusively proved that the gain with the heaters more than compensated for the low steam consumption when running without them. So far as is known, however, the idea has not been applied to turbine practice. Its possibilities warrant further analysis.

Emergency Transformer Connections

While the operating engineer has been greatly assisted by the coöperation of the designing engineer, who has developed apparatus which have made possible the universal applications of electrical energy, nevertheless the task falls to the operating man of successfully commercializing these products into service, which is the foundation of the business of all public utilities. To accomplish this task the operating man has been heavily taxed in the performance of his intricate duties; he must constantly, if not instantly, give proofs of great resourcefulness and ingenuity in the solution of an infinity of problems arising daily from the emergencies of a multitude of requirements imposed by the diversity of ever-growing applications and changing operating conditions and other features incumbent to the central-station service.

In most instances the solution of the problem must be forthcoming promptly and met successfully, because the customer is loath to consent to any delay in obtaining satisfactory service.

One of the most common instances demanding a prompt action is found in transformer installations, where the nature of the service requires either a special voltage or phase transformation not readily or easily obtainable from standard apparatus generally carried in stock, or from supply lines, both conditions liable to cause either delays or unsatisfactory service, and naturally a dissatisfied customer. In such cases an emergency but reliable substitute is utterly necessary to supply the service, or promptly resume the same in case of failure of a transformer not easily replaceable.

Emergency or even permanent connections can be made by means of ordinary commercial or pole-type transformers having a ratio of transformation of twenty to one or ten to one, and generally provided with two secondary and two primary coils that can be connected in series or parallel. This type of transformer lends itself to a great number of combinations, a few of which are described elsewhere in this issue, in an article on "Emergency Transformer Connections," and others will be treated in a later issue.

Many readers undoubtedly desire to do their bit for the Government in subscribing to the "Liberty Loan." The bonds will be in denominations as low as fifty dollars and applications to most any commercial bank will be taken care of without any commissions. If the first issue is oversubscribed there will be more to follow.

Within the past few weeks at least two of the large central-station companies have been seriously handicapped for capacity through failure of large turbogenerators, one a thirty-five thousand kilowatt machine and the other a thirty thousand. This will give hope to those who have argued against putting too many eggs in one basket, and who have been content with a greater number of moderately large units.

The American people are ready for sacrifice and deprivation to meet the exigencies of the times, but woe be if they get the impression that the necessities of war are being used as an excuse for new or continued exactions. The action of the interests that have always been trying to emasculate the engineers' license law of Massachusetts in pleading that it be practically shelved so as to give an unrestricted supply of labor in this field during the war smacks of this sort of an effort. Be careful, gentlemen.

As an example of the exaggerations we have been hearing as to airplane performances, it is interesting to note what Major Rees, the aviator who accompanies the British War Commission, has to say in regard to the matter of speed. He places the speed of airplanes at the front as about one hundred and twenty-five miles an hour as a maximum, an increase of only seven miles during the past year. This is decidedly different from the tales we have been hearing of speeds of one hundred and fifty to one hundred and sixty miles an hour and makes the performances of our own fast machines nothing at all to be ashamed of, when we consider how very little actual experience we have had with them.

Herbert C. Hoover, head of the American Food Board, says: "To carry the Allies over until the next harvest we must reduce our wheat consumption thirty per cent. This means that every man, woman and child must forego at least one loaf of wheat bread per week and eat something else or less generously." Surely this is a little sacrifice to make in view of all that it means. The line upon the Scarpe and the Aisne stands not only between the hordes of Hindenburg and Paris or London, but between them and America. If from no more patriotic or less selfish a motive, one should confine himself and his to their necessities now in order to avoid scarcity and exorbitant prices in the autumn. What is not wasted or needlessly consumed today may avert, if not a famine, an era of prices which may make the present high cost of living look dirt-cheap.

Correspondence

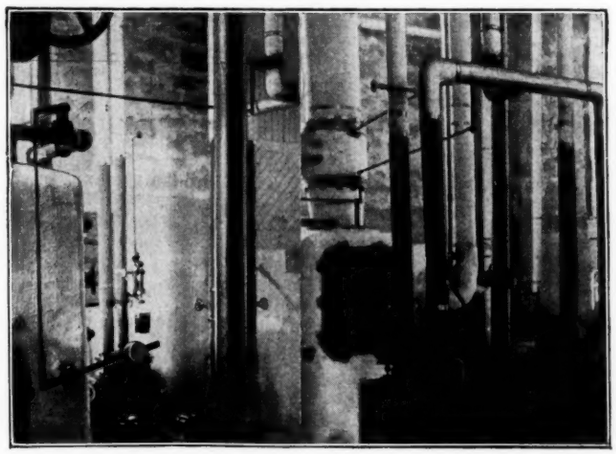
Equalization of Cutoff

In reply to Mr. Haines in the issue of Apr. 17, page 533, relative to the equalization of the cutoff in Corliss engines, I desire to say that nearly twenty years ago an equalized cutoff was put into public use on the engines built for the pneumatic mail system by the Rand Drill Co., of Tarrytown, N. Y., and the Hewes & Phillips Iron Works, of Newark, N. J., and has been in public use ever since; and there are many in use in the City of Philadelphia. JAMES NAYLOR.

Arlington, N. J.

Water Level in Feed-Water Heater Controls Feed Pumps

In our plant all the steam from the boilers is condensed and returned to an open feed-water heater that had, when first installed, a regular float control system in the supply pipe at the top of the heater. This arrangement did not work well in our case, as we would at times have too much water in the boilers or would be wasting it at the overflow, so the following changes were made: The control valve was taken out of the supply line and an ordinary gate valve put in its place, to be used when cleaning the heater, and the control valve was placed in the steam line leading to the boiler-feed pumps, and connected with the float in the heater by means of light rods and levers. As the water rises in the heater, it raises the float and opens the throttle of the boiler-feed pumps and speeds them up, in this way governing them at all times and keeping the boilers supplied. The spray for the vacuum pump makes up the losses at the drains from the oil traps, etc.



FLOAT IN HEATER CONTROLS SPEED OF PUMPS

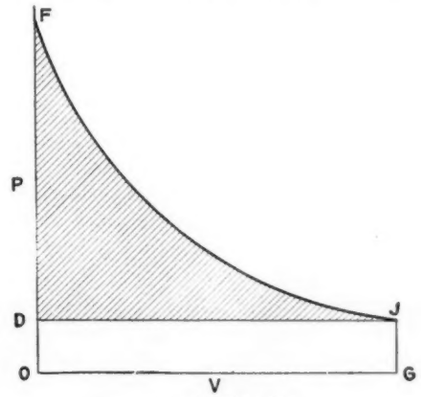
At first we had some annoyance on account of the float becoming water-logged, but this was overcome by punching a hole in the float so it would be full of water all the time and placing a lever or arm immediately outside the heater with a weight on it to counterbalance the weight of the float. This arrangement has given us entire satisfaction for more than two years of constant use. The illustration shows, in two views, the weighted lever on the side of the heater with a rod extending to the rocker arm above and another extending to the control valve in the steam line to the pumps from the opposite end of the rocker shaft. R. F. BONGBERG.

Flagstaff, Ariz.

Energy Released by Explosion

I submit the following for consideration in connection with the problem on page 474, Apr. 10, "Energy Stored in a Boiler Under Pressure," and covering another phase of the matter; namely, the time element.

1. The heat equivalent, per pound, of the energy released when the pressure upon water at 338.1 deg. F. (115 lb. abs.) is suddenly reduced to 14.7 lb. abs. is 19.8 B.t.u., but of this amount only 10.9 B.t.u. is effective in producing the destructive or disturbing effect, arrived at as follows: The PV diagram is employed rather than the temperature-entropy diagram, because a boiler explosion is a single process and not a cycle, and entropy diagrams can show only the net work of cycles and not of processes. The work done by the steam in expanding adiabatically is represented by the area $OFJGO$. Let



PV DIAGRAM

W = Internal energy at F — internal energy at J = $I_1 - I_2$

$I_1 = h_1 = 309$

$I_2 = h_2 + x_2\rho_2 = 180 + (0.1217)\ (897.6) = 289.2$ B.t.u., where x_2 is the quality and ρ the heat equivalent of the internal work at J.

$W = 309 - 289.2 = 19.8$ B.t.u.

2. But only the shaded area $DFJD$ is *effective*, just as the back pressure must be subtracted from the mean forward pressure in an engine in order to give the mean effective pressure or net work during the stroke.

$$ODJGO = \frac{26.79 \times 0.1217 \times 144 \times 14.7}{778} = 8.9\ B.t.u.$$

26.79 is the sp.vol. in cu.ft. per lb.

(neglecting the small volume of water)
therefore

$$DFJD = 19.8 - 8.9 = 10.9 \ B.t.u.$$

This result is numerically equal to that obtained from the area *DFJD* of the entropy diagram, because practically no work is done during the process of heating the water along *DF*, and therefore the net work of the cycle *DFJD* is the same as the effective work done during the explosion process from *F* to *J*.

3. In like manner, referring to Fig. 6, page 476, the energy released when a pound of steam expands adiabatically from 115 lb. per sq.in. down to atmospheric pressure is the difference of the internal energies, or 132.2 B.t.u., but the effective work done is only the area *BCH*, or $BCH = 132.2 - HCDE$. But

$$HCDE = 144 \times 14.7 \left[(26.79 \times \underset{\text{quality}}{0.885}) - 3.88\right] \frac{1}{778}$$

$$= 54.0 \ B.t.u.$$

therefore

$$BCH = 132.2 - 54.0 \text{ or } 78.2 \ B.t.u. \text{ per lb. of steam}$$

In my opinion the question finally resolves itself into what constitutes an explosion. In general an explosion is a very rapid expansion due to a sudden rise in pressure of the explosive substance. Obviously, it is the pressure in excess of that of the surrounding medium that produces the explosive effect, for certainly one would not say that the steam formed by boiling water at 212 deg. is explosive, although the steam does a certain amount of work on the environment in making room for itself. There is another side to this question; namely, the time element, which is the most important factor in an explosion. Of what value would gunpowder be if it were not possible to develop its energy very rapidly and so deliver an enormous horsepower? The energies used up in two different phenomena may be the same, but the rates may be very different, and thus one process may be mild, while the other may be very violent as regards its destructive efforts. For example, the evaporation of 1000 lb. of water per hour to supply a 50-hp. engine would not involve explosive violence, but if the boiler should be suddenly ruptured to such an extent that 1000 lb. of its water would escape and be converted into steam within a few seconds, an enormous horsepower would be developed, although a less amount of energy would be used than in the previous case. It would therefore seem that from the practical standpoint it matters little how much energy is effective in producing destruction, whether 10.9 B.t.u. or 19.8 B.t.u. per lb. of water, but rather how rapidly (or how suddenly) the energy is released. In conclusion, then, the energy released per pound of water under the conditions stated is 19.8 B.t.u., of which 10.9 B.t.u. is effective (theoretically) in producing destruction, but the real factor to be considered is the rapidity with which this energy is released.

R. B. Fehr,
Asst. Professor of Mechanical Engineering,
State College, Penn. State College.

The discussion concerning the destructive force of the hot water in a boiler that is about to explode is certainly interesting. So, also, is the subject of the misnamed "external latent heat," otherwise known as *Apu*.

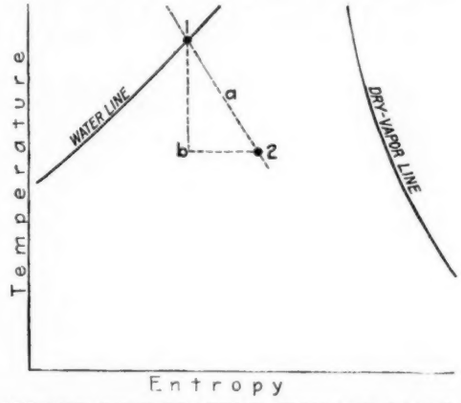
In order to get this matter of "internal energy" properly straightened out, it is necessary to get down to fundamentals. For this purpose the water must be considered as a collection of molecules. When the temperature of water is increased, energy must be supplied. This energy goes to increasing the activity (kinetic energy) of the molecules. As long as the water stays in liquid form, it means that the molecules have not yet acquired velocity sufficient to permit them to get away from the intimate sphere of attraction of the neighbor molecules. When the water gets to a certain temperature, depending on pressure, any further addition of heat energy causes a change of state without change of temperature. This is vaporization. What actually happens is that one by one the molecules acquire sufficient kinetic energy (velocity) so that they shoot out from the main mass of liquid and get away from the intimate sphere of attraction. This separation of the molecules requires energy to be used in two ways at the same time: (1) To pull the molecules apart against their gravitational attraction; (2) displacing something in order to obtain the necessary space for the separation of the molecules.

The energy required to overcome the mutual attraction of the molecules is called the internal latent heat, and is denoted by C. The energy required to displace some surrounding medium is termed "external latent heat" and is symbolized *Apu* (*p* is lb. per sq.ft., *u* is change of volume in cu. ft., the product *pu* is foot-pounds, *A* is a conversion factor to transform foot-pounds into heat units). The *Apu* energy is never a part of the steam; the steam simply transmits it, like the atmosphere transmits wireless waves.

Constant Use Necessary to Constant Pressure

It is impossible to generate steam at constant pressure, unless the steam is removed as fast as it forms. What happens to the steam pressure when the engine suddenly stops is that the energy that has been going into *Apu* now goes into compressing the steam that already is in the boiler, and all the engine has to do with this *Apu* is that it furnishes the space required in order to separate the molecules. All the work that is done from admission to cutoff is done simply and solely by the *Apu* of boiler pressure. Consider a boiler with a very large steam space; imagine the fire to be suddenly withdrawn, the pumps started and feeding water at steam temperature. If the pump capacity was great enough, would it not be possible to continue to run the engine just as well as with the fire —of course stopping when the steam space was filled with water? In this pipe-dream the *Apu* came from a source which was not fire, nor heat, but was the energy which ran the feed pump. Continuing with the engine, after cutoff there is no longer any external source of energy, and the *Apu* has been used up. Therefore the work done in the cylinder during expansion must be done at the expense of the internal energy that is stored in the steam. This internal energy is made up of the heat of the liquid (*q*) and of C, both at boiler pressure. The process of converting the internal energy into external work is by permitting infinitesimal increases of volume to occur at constant pressure, then dropping the pressure and repeating. In other words, it is the integral of an infinite number of *Apu* values, each at a pressure less than the preceding one. When the pressure drops, the internal energy of the higher pressure is greater than at the lower, and the excess may go into *Apu*.

The definition of adiabatic is: No change of heat as heat. During adiabatic expansion heat may (or may not) be transformed into other forms of energy, which in turn may (or may not) be removed. The idea is that the substance must be thermally isolated. In a steam-turbine nozzle, heat is transformed into kinetic energy of the mass and the blades take up this energy. In a throttling calorimeter this kinetic energy is converted into heat again, and the heat goes back into the steam. Both processes, if ideal, are adiabatic. The ideal expansion through the nozzle is also isentropic = constant entropy. Isentropic expansion is always adiabatic, but adiabatic may not be isentropic, as for instance the porous-plug expansion used in scientific experiments. Entropy is a useful servant and an awful master. The temperature-entropy diagram can be truly applied only to a reversible process. Actually, no process is truly reversible. In boiler explosions we have a process that requires more than the usual stretching of imagination in order to make it reversible. But if we must put them on the temperature-entropy diagram, then let's do it this way.



MODIFIED TEMPERATURE-ENTROPY DIAGRAM

Here is a pound of water at point 1. Boiler now blows up. No time available for water to lose any heat to surroundings, so maybe we find it at point 2, with same associated energy as at point 1. We don't know exactly how it got to point 2; some of it may have expanded down the constant heat line 1-*a*-2, as in the porous plug. Some of it may have expanded isentropically to point *b* and then have changed kinetic to heat energy at constant pressure, along *b*-2. Path 1-*b*-2 is what we suppose a throttling calorimeter process to be if the nozzle is designed with the care used on a steam-turbine nozzle. The greater portion of the mass probably followed paths in between 1-*a*-2 and 1-*b*-2. At any rate the water is now wet steam, with a quality *x*. At 1 the energy is all in one form, heat of the liquid, an "internal" form. At 2 the energy is in three forms, heat of the liquid, internal latent heat, and *Apu*. Of course for point 2 we have to multiply both C and *Apu* by the quality. The *Apu* has been dissipated in moving the ironwork, bricks, etc., and in setting up sound waves; q_2 *and* xc_2 are still harmless in the H_2O molecules—except for scalding properties.

If all the molecules go to point 2, the difference of the internal energies gives about 10 B. t. u. per lb. available for pressure-volume change work. If all the molecules end at point *b*, there is about 20 B. t. u. per lb. available for pressure-volume change work combined with kinetic energy work. It is almost a certainty that all the molecules will not travel the same path, and that none will travel either of the routes 1-*a*-2 or 1-*b*-2. They will follow courses in between, all ending somewhere on line *b*-2 but not at the same point. Therefore the minimum energy available for destruction is 10 B. t. u. per lb. and the maximum is 20. Any kinetic energy will probably be absorbed by the surroundings before it can be reconverted into heat and absorbed by the water. The numerical values given are upon the assumption that the 338.1 deg. F. water expands to 14.7 lb. per sq. in. This assumption is hardly justifiable. The natural tendency for all violent actions is to overtravel the limits ordinarily expected. There is another reason for doubting the accuracy of the 14.7 lb. per sq.in. abs. assumption, and that is the fact that the vapor-pressure of the water in the atmosphere is generally not more than 0.5 lb. per sq. in. abs. Water evaporating freely into the air has its temperature-pressure equilibrium at more nearly 60 deg. and 0.25 lb. per sq. in. than at 212 deg. and 14.7 lb. per sq. in. If this lower pressure is the one to which the water goes, then the energy available for destruction, per pound of water, is between limits of about the order of 15 and 70. My personal prejudice in the matter is that the actual value is nearer the upper limit under the particular conditions involved, but I doubt if we shall ever be able to learn what actually does happen.

VICTOR R. GAGE,
Asst. Prof. Mech. Eng.,
Ithaca, N. Y. Sibley College.

The problem under discussion on page 474 of the Apr. 10 issue, regarding the energy stored in a boiler under pressure, is not an academic proposition, but an actual one where our only interest is in the available energy tending to cause an explosion. We know that if we have some process represented on the *p-v* plane by the line *ab*, Fig. 1, the external work for an elementary strip is

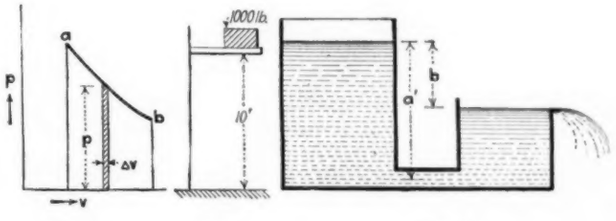


Fig. 1 Fig. 2 Fig. 3

FIGS. 1 TO 3. DIAGRAMS ILLUSTRATING THE PROBLEM

given by the area ($p \times \Delta v$), just as when a 10-lb. weight is lifted 2 ft. the work done is equal to the weight (10 lb.) times the distance (2 ft.) or 20 ft.-lb. The total energy developed by the process *ab* is given by the sum of all the elementary strips, or $\int_b^a p\Delta v$, where the pressure is considered as calculated from the absolute zero of pressure. But this is not the condition under discussion. In Fig. 2 a 1000-lb. weight is represented as being 10 ft. above the surface of the earth. It has $1000 \times 10 = 10{,}000$ ft.-lb. of potential energy in virtue of its position. If we dig a hole in the ground, we can get more energy from it than the amount just given, but it would be absurd to consider such a condition as being practical or to reckon the energy in a body from its position with regard to the center of the earth.

If we have a waterfall of *b* feet, is there any advantage in digging a hole so as to give an apparent head of *a* feet (Fig. 3)? So in the case of the boiler explosion

already mentioned, the 19.77 B.t.u. represents the available or possible energy, but only 10.8 B.t.u. is obtainable for creating the explosion. H. J. MACINTIRE.

Seattle, Wash.

I have read with interest Mr. Low's analysis of the "Energy Stored in a Boiler Under Pressure," in the issue of Apr. 10, page 474. From his clear analysis it is hard to see how the conclusion can be doubted; namely, the energy available for mechanical destruction from a boiler explosion is that due to adiabatic expansion of hot water from 338.1 deg. to a mixture of steam and water at 212 deg., or about 10.8 B.t.u. per pound of water.

Suppose we consider the water to be expanded in a perfect steam engine. With adiabatic expansion there is no doubt 10.8 B.t.u. would be available through expansion for useful work, and the rest of the heat would be rejected to the atmospheric exhaust. If the heat-working medium were expanded adiabatically to a volume corresponding to that for atmospheric pressure, but exhausted against absolute zero back pressure, the mechanical energy available would be 10.8 + 8.87, or about 19.7 B.t.u. But where there is a back pressure of 14.7 lb. per sq.in., the 8.87 B.t.u. must be lost in overcoming this pressure to make room for the steam at the increased volume. Similarly, in the case of a boiler explosion, 10.8 B.t.u. is available through expansion, but 8.87 B.t.u. is lost in pushing away the atmosphere to make room for the steam at its increased volume under a lower pressure. Steam in a boiler explosion acting in every direction, acts just as steam would act in an infinite number of small engine cylinders operating radially from a given point, so that the total mechanical energy equals the destructive effect of the explosion.

So far as damage is concerned, the 10.8 B.t.u. is quite sufficient. Assume a boiler weighing 10,000 lb., containing 15,000 lb. of water to explode under the given conditions. If all the energy were available—at 100 per cent. efficiency and expended in lifting the boiler straight into the air, the height reached would be

$$\frac{778 \times 10.8 \times 15{,}000}{25{,}000\ (\textit{total weight of boiler and water})} = 5000+\ ft.$$

In other words, the boiler would be "blown out of sight."

New York City. HAYLETT O'NEILL.

Pump Exhausting Into Suction

Leakage into a tunnel necessitated the temporary use of a steam pump, but there was no convenient line to which the exhaust could be connected and exhausting into the tunnel was objectionable. It occurred to me that the exhaust could be directed into the cold-water suction line after the pump was started, similar to the practice with some small pumps I have seen used to feed the boilers of agricultural engines.

I would like to have the opinions of other engineers as to whether this plan would work on a pump as large as 8 x 5 x 10 in., 8-ft. suction and 30-ft. discharge head.

Hyattsville, Md. J. C. HAWKINS.

[Patents (probably expired now) have been granted for just such an arrangement, and in fact a jet condenser is similar and it takes care of more than the exhaust from the pump. There is sometimes difficulty in restarting if the suction is lost.—Editor.]

Cleaning Surface Condensers

In response to the editorial request in the issue of Mar. 20 that engineers discuss the various methods and means for cleaning surface condensers, the following is submitted:

Fig. 1. is a sectional elevation of a condenser for a 15-million gallon triple-expansion pumping engine, in the

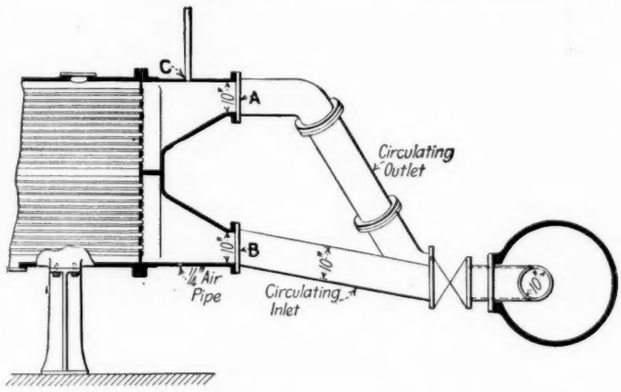


FIG. 1. WATER CONNECTIONS, WATER-WORKS CONDENSER

Baden Station of the St. Louis water-works. Condensing water is forced, or deflected, through the condenser by means of an adjustable baffle in the main pump suction, between the inlet and outlet circulating pipes, as indicated in Fig. 2. The condenser is of the water-tube type, having 2130 sq. ft. of surface to condense approximately 8600 lb. of steam per hour. The circulating water is the softened and filtered water for city consumption, but has been found to produce a hard scale that, while it does not accumulate rapidly, interferes seriously with the desired vacuum if means are not used to remove it.

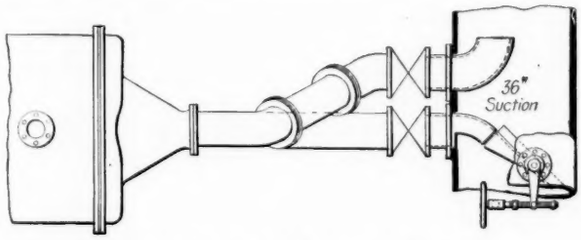


FIG. 2. PLAN VIEW OF INLET AND OUTLET CONNECTIONS

It has been found necessary to thoroughly clean the condenser every 12 to 18 months. An analysis of the scale shows it to be composed of calcium carbonate, 29.9 per cent.; calcium sulphate, 4.7 per cent.; magnesium hydroxide, 22.6 per cent.; silica, 38.1 per cent.; iron and aluminum oxides, 4.7 per cent.

Cleaning is effected by blanking off the circulating pipe connections with blind flanges at the points marked *A* and *B* and providing a 2-in. vent pipe *C* extending about 4 ft. above the top of the condenser. A ¼-in. air pipe is connected into the water inlet at the bottom of the condenser through which a small stream of air is kept bubbling. The water side of the condenser is first filled about three-quarters full of water, and 40 gal. of commercial muriatic acid is added, after which it is entirely filled with water, making a 6 per cent. acid solution. At first the action of the acid is quite violent and water spatters out of the vent pipe at the top. The pur-

pose of the air is to keep the mixture of acid and water agitated, and it requires from 36 to 48 hours to clean the condenser in the manner described, depending upon how much scale has accumulated. When the acid has been in the condenser for the proper period, it is withdrawn, and after being thoroughly flushed with water, the tubes are bright and clean with no evidence of injury. The vacuum is restored to its original value, and the condenser is ready for another period of service. While probably not applicable to some types of condenser, this process can be used successfully on many.

A point frequently overlooked in the design of the water-works type of condenser, especially those of the steam-tube type, is an adequate supporting plate for the tubes at the center. Failure to provide the middle support often results in an annoying rattle, and with sandy, gritty water frequently causes leaks from the actual rubbing through of the tubes.

Tubes Should Be Liberally Spaced

In cases where the circulating water contains much sand and mud, which is apt to settle in the ends of the condenser and obstruct the space between the tubes, the tube spacing should be free and liberal. Where the condensing surface necessary does not exceed, say, 4000 sq. ft., it is often possible to arrange the tubes in horizontal and vertical rows, leaving ample room between them for easy clearing with a scraper or hose. Handholes properly located in the shell will give full access for the purpose of clearing, and materially aid in the operation.

The St. Louis water-works recently found it necessary to remodel two steam-tube condensers in which the tubes were staggered and not accessible for cleaning. New tube sheets and support plates were provided, with the spacing arranged in vertical and horizontal rows. Handholes located properly made it possible to direct a jet of water from a hose between the tubes and keep the spaces clean and open. While the condensing surface was reduced, the average vacuum possible was improved. It should be remarked, however, that these were water-works condensers through which passed the entire volume of water pumped.

H. F. Gauss.

St. Louis, Mo.

Following is the way we clean our condensers in a station where the water is fresh, but carries a large amount of sediment and other impurities emptied in the stream from manufacturing plants above the station. The substance formed on the inside of the tubes is of a black, slimy nature and is from $\frac{1}{8}$ to $\frac{1}{4}$ in. thick. It is soft, but it affects the cooling surface so much that we have to clean about every four weeks. One condenser has 13,000 sq.ft. of cooling surface and serves a 5000-kw. turbine.

We have tried several methods, such as blowing with steam, sandblasting and washing with a high pressure of water from a hose, but the best thing we have found for our case has been the steel rice-wire brush with jets of water at 100 lb. pressure behind it. The brush has a $\frac{1}{8}$-in. pipe shank. We made a coupling of brass $\frac{1}{8}$-in. pipe size at one end and $\frac{3}{8}$-in. at the other. Six $\frac{1}{16}$-in. holes are drilled in the shoulder of this coupling. The brush is screwed into the small end of the coupling, and a $\frac{3}{8}$-pipe long enough to reach through the tube and a hose is attached to the pressure water.

These jets of water work the dirt away that the brush has loosened up and clean the brush when it has gone through the tube—and it is important that it should go clear through. The water keeps the wire brush from scratching the tube as it would if forced through dry. The time to clean the condenser is determined by the vacuum and also the temperature of the hotwell water. If the condenser is tight and the dry-vacuum pump is in good order and the vacuum is still poor, it is time to look the tubes over.

We use two brushes and two men to a brush. One can do it, but the long slender pipe is hard to manage, so two men can do the work much faster. This condenser has 2900 one-inch tubes, and four men can clean the tubes and put the head on in about 16 hours if the gasket is not spoiled. Before replacing the head, we put on a good thick coat of graphite and cylinder oil so the head can be removed without tearing the gasket, thus saving the expense of a new one.

Expense of Cleaning Well Repaid

It costs from $22 to $25 each time we clean the condenser, but it is money well spent. The last time the top half was cleaned one night and the bottom the next night, so we had a chance to see how much of a gain was made with the condenser half-cleaned as well as with all the tubes clean.

We find that the small bank of tubes that cool the air going to the dry-vacuum pump suction needs cleaning about every week, as this pump will remove a lot more cool air than it will when the air is warm, and especial attention should be given to these tubes for that reason.

Results Under Different Conditions

The following readings will show the gain in vacuum after cleaning:

Feb. 26, condenser very dirty, reading taken at 11 a.m., when the load is heaviest. Temperature of steam, 515 deg. F.; pressure, 190 lb.; first-stage pressure, 30 lb.; barometer, 29.9 in.; vacuum, 28 in.; hotwell, 98 deg. F.; inlet cooling water, in 33 deg. F., out 52 deg. F.; boiler feed, 206 deg. F.; load, 5000 kw.; P. F., 75 per cent. (valves open 4¼).

Feb. 27, condenser top cleaned. Steam temp., 510 deg. F.; pressure, 190 lb.; first-stage pressure, 29 lb.; barometer, 29.74 in.; vacuum, 29 in.; hotwell, 59 deg. F.; cooling water, in 34 deg. F.; out 49 deg. F.; boiler feed, 190 deg. F.; load, 5200 kw.; P. F. 76 per cent. (valves open 4).

Feb. 27, condenser all cleaned. Steam temp., 530 deg. F.; pressure, 190 lb.; first-stage pressure, 29 lb.; barometer, 30.34 in.; vacuum, 29.60 in.; hotwell, 46 deg. F., cooling water, in 32 deg. F.; out 48 deg. F., boiler feed, 200 deg. F.; load, 5400 kw.; P. F., 77 per cent. (valves open 4).

Mar. 1. Steam temp., 500 deg. F.; pressure, 191 lb.; first-stage pressure, 29 lb.; barometer, 30.32 in.; vacuum, 29.5 in.; hotwell, 46 deg. F.; cooling water, in 32 deg. F., out 47 deg. F.; boiler feed, 200 deg. F.; load, 5200 kw.; P. F., 78 per cent. (valves open 3¾).

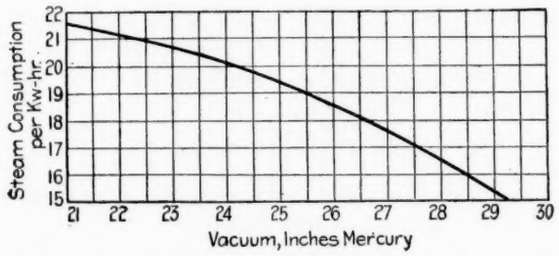
This pressure and superheat are both taken at the throttle.

F. B. Wheaton.

East Bridgewater, Mass.

Cleaning small condenser tubes by boiling out with chemical solutions is more effective in loosening the tube packing than the scale, and the use of acids that attack the metal of course should not be tolerated. I claim that the only effective method of removing scale from condensers is by mechanical cleaners. With an air or steam-driven mechanical cleaner made expressly for condenser tubes, an ordinary-length tube can be cleaned in from 30 to 60 sec., providing the scale is not exceedingly thick.

Not long ago an air-operated mechanical cleaner was tested by the manufacturers of small condenser tubes for the purpose of determining the effect on copper tubes. It was found that with medium pressure the cleaner



RELATION OF STEAM CONSUMPTION TO VACUUM

easily cut its way through the scale leaving a clean, smooth surface, without marring or doing any injury to the tube, proving this to be a safe method.

The illustration shows graphically the relation of steam consumption to vacuum. A drop of two inches in the vacuum, that is, from 29 to 27 in., increases the steam consumption per kw.-hr. from 15¼ to 17½ lb. (nearly 15 per cent.) and cuts down the power obtainable from a given installation. Since the vacuum depends directly upon the rate of heat transmission through the tubes, it can readily be seen that a coating of scale rapidly decreases the heat transmission and makes for a reduced vacuum.

M. M. SELLERS.

Springfield, Ohio.

We are compelled to wash the inside of our condenser tubes twice and sometimes three times a week, while on the outside or on the steam side proper once a year is sufficient, as it is found that the deposit of oil or grease is not heavy enough to warrant cleaning oftener.

Our condenser contains 966 tubes ⅝ in. diameter by 8 ft. long, and washing is done with a short length of ½-in. pipe coupled to a 1-in. hose, taking water at 100 lb. and holding the nozzle for a moment at the end of each tube. Care is taken to put the pressure against the flow of the circulating water, as it will be observed that any particles too large to pass through the tubes and lodging in or against the ferrules can more easily be removed. This operation requires about twenty minutes' time and gives entire satisfaction, being done while the mud is soft. Of course this means exhausting to the atmosphere, but fortunately does not interfere with the general operation of the plant.

In cleaning the interior, or steam side, of the condenser we use a liberal quantity of boiler compound, heating the solution to 180 deg. for about eight hours; then remove the lower plates and wash thoroughly with water taken from the boiler-feed line, and apparently no damage is done to the tube packing by the compound. Some years ago it was customary to "sponge" the tubes—that is, force a rod through each one—but this was abandoned on account of the damage done to the older or weaker tubes and the labor required.

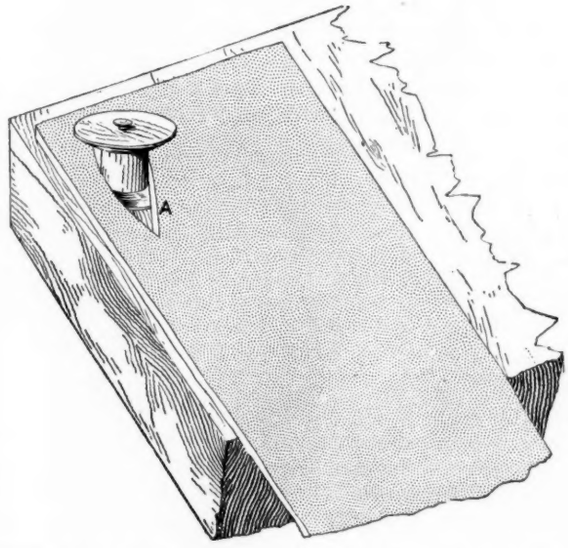
Tests demonstrate the gain in steam consumption when the higher vacuum is maintained on our "Ball-Wood" engine, rated at 500 hp.; the water rate is 16.26 lb. per i.hp. at 27 in. vacuum, but is increased to 17.45 lb. at 22 in. vacuum. The reader can therefore draw his own conclusion as to the advisability of frequent condenser cleaning, especially where the cooling water is more or less dirty. In our case the water contains a large percentage of mud and sediment and our condensing equipment is entirely inadequate on account of the overloaded condition.

Where a high vacuum is obtainable through frequent washing, it is gross negligence on the part of those in charge to allow a reverse condition to exist.

Emeryville, Calif. FRANK G. SEAVER.

Cutting Leather Belt Laces

On page 361, issue of Mar. 13, B. Z. Reiter adds one more to a long list of ingenious and simple home-made devices for the frequent job of cutting belt laces from the hide, a job requiring two men and a pocketknife to do satisfactorily. When one tries the operation alone, using a bench vise for the other man, it becomes an awkward, difficult job because the lace stretches and no matter how hard the hide is pulled, the lace is not kept taut, so in



HOW THE HIDE IS HELD WHILE CUTTING A LACE

the absence of the other man one begins to invent. I have not invented another cutter, but have made a device to take the place of the other man. The illustration shows a common thread spool turning loosely on a nail driven near the edge of the bench. The hide is first cut at *A*, the width of the lace desired, and the slit is slipped over the spool. As the lace is cut, the spool rotates as much as the lace stretches more than the hide, keeping it taut to the finish. This reduces the whole equipment to a jackknife, a spool and a nail.

R. MANLY ORR.

Vancouver, B. C., Canada.

Inquiries of General Interest

Overtravel of Valve—What is meant by overtravel of a valve? G. P.

The travel of a valve is often more than sufficient to give a full opening of the port. The excess is called overtravel.

Crowning of Pulley Faces—What is the rule for the proper amount of crowning for a high-face pulley? C. M.

There is no fixed rule for the rise or convexity that should be given to the face of crowning pulleys. The amounts quoted by different authorities vary from ¼ of 1 per cent. to 4 per cent. of the width of the face.

Temperature for Storage of Ammonia Drums—What temperature of surrounding atmosphere is safe for storage of ammonia shipping drums? A. H.

The drums should be stored in an atmosphere below 80 deg. F. well away from warm walls of boiler settings, steam pipes or other sources of heat and should be shaded from the sun's rays or other radiant heat to prevent dangerous rise of temperature and pressure.

Accessibility of Lost-Motion Adjustment—Why are not duplex boiler-feed pumps provided with means for adjusting the lost motion of the steam-valve gear without removal of the steam-chest cover? T. R. B.

For small pumps it is preferable to provide means of adjustment that will require the pump to be stopped and have the steam-chest cover removed, thus to better guard against anyone meddling with the adjustments which the manufacturer has made for the running conditions. Large pumps generally are provided with lost-motion links that are adjustable from the outside, and large pumping engines that are operated by skilled attendants are usually provided with outside lost-motion links for adjusting the length of stroke while the pump is running.

Critical Speeds of Steam Turbines—What is meant by the critical speed of a steam turbine? C. E. F.

The term "critical speed" applies to any speed at which the parts of a rotating shaft, machine or mass are not in running balance. Usually, it is not possible to balance the parts of a rotating mass to make its center of gravity coincide exactly with the geometric center about which it revolves. In any machine like a steam turbine, when these two centers do not coincide excessive vibrations are produced. This phenomenon occurs at definite speeds called "critical" for every rotating mass. From the arrangement or self-adjustment of the material the rotating masses may not interbalance as well at low speeds as at higher speeds, and there may be several "critical" speeds of the turbine at lower velocities than the full speed at which it runs without dangerous vibrations.

Bridge-Walls for H. R. T. Boiler Settings—In an ordinary brick setting of a horizontal return-tubular boiler, what determines the cross-sectional area of the space bounded by the top of the bridge-wall, the side walls and the under side of the boiler; and which is considered better, to have the top of the bridge-wall extend horizontally between the side walls or shaped to the curvature of the boiler? W. G. B.

The cross-sectional area of the space over the wall must be large enough not to check the draft and therefore should be somewhat larger than the cross-sectional area of the tubes. In hand-firing, some benefit is derived in improvement of combustion of fresh fuel in having the gases more thoroughly mixed and heated in their passage over the bridge-wall, but raising the bridge-wall for that purpose has the disadvantage of centralizing the impingement of the hottest gases on the boiler shell and in better practice bridge-walls are built only high enough to prevent the fuel from falling off the grates.

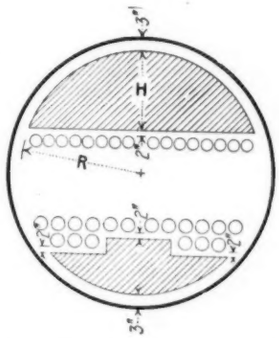
The shape of the wall, whether flat on top or curved to correspond with the boiler shell or whether made with vertical or sloping sides, appears, according to tests, to make no difference in furnace economy.

Economy of Combining Pump and Engine Exhaust—How would the economy of a noncondensing plant be affected by connecting the exhaust of a boiler-feed pump and of a house pump into the exhaust of the engine before it goes through a closed feed-water heater? G. B.

Combining the exhausts will necessarily increase the back pressure of the engine and the pumps, and in that respect might be more detrimental to economy than beneficial from simply increase of temperature of the feed water, although in a plant that is provided with a feed-water heater and exhaust connections of ordinary proportions, the effect of increase of back pressure would not be appreciable. For development of the same power the increase of back pressure would require the engine and pumps each to be supplied with more steam. The advantage or detriment to plant economy would depend on the utilization made of the combined exhaust for heating, or other purposes, that otherwise would require more live steam than the additional steam required by the pumps and the engine. The additional steam required by the engine could be determined, with sufficient accuracy for practical purposes, by taking the difference of steam consumption, computed from indicator diagrams taken with and without the increased back pressure when the pumps and the engine are developing average power.

Area of Segments of Heads To Be Stayed—A horizontal return-tubular boiler is 54 in. diameter. The distance from the top of the tubes to the highest part of the shell is 20 in. What is the area which the braces must stay above the tubes? A. S. B.

According to the A. S. M. E. Boiler Code, "The area of a segment of a head to be stayed shall be the area inclosed by lines drawn 3 in. from the shell and 2 in. from the tubes," as shown by the shaded portions of the figure. The area required may be found by the formula,



$$\frac{4H^2}{3}\sqrt{\frac{2R}{H}} - 0.608 = \text{area of segment stayed, in square inches.}$$

where H = distance from tubes to shell, minus 5 in. and R = radius of boiler, minus 3 in. In the example H = 20 — 5, or 15, in. and R = ½ of 54 — 3, or 24, in., and by substituting these values in the formula, the area of segment to be stayed is found to be

$$\frac{4 \times 15 \times 15}{3}\sqrt{\frac{2 \times 24}{15}} - 0.608 = 483 \text{ sq.in.}$$

Results from Failure of Engine Governors—What would happen if the spring on a shaft governor should break while running? What would result if the governor belt of a Corliss engine should run off or break while the engine is running? W. F.

If the spring of a shaft governor should break while running, without obstructing the operation of other working parts, the governor weights would instantly move out to a position corresponding to the shortest cutoff and adjust the valve-gear to admission of less steam. Hence with the same load the engine would slow down in speed, and with most shaft governors, the supply of steam would be so completely shut off that the engine would stop.

If the belt of an ordinary Corliss engine governor should break or run off, the governor would stop, and if not prevented by the starting pin, safety collar or other obstruction, the governor would drop to a position that would swing the regular trip cams out of the way and prevent the valve-gear from picking up the valves for admission of steam to the cylinder, and the engine would come to rest. But if not permitted to drop low enough to turn the cutoff cams out of operation, the valve-gear will continue to pick up and the point of cutting off being later than required by the load, the engine will run away unless the supply of steam is quickly checked by hand or by the operation of an automatic safety stop.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Principles of Power-Plant Management*

By Walter N. Polakov†

SYNOPSIS—Outlines the methods of inquiring into the factors and details that influence the cost of power. A disinterested investigator should make the inquiry. The author states that whether power as generated in 90 per cent. of the mills is cheaper or more expensive than the power the owners could buy, there is no assurance—one does not know without investigation.

In the determination of the cost of generating power on the premises we must consider not only the elements of cost, but the efficiency of operation in the past and future. Moreover, convenience, value of space occupied by the plant, safety, amount of money tied up, use of byproducts, cost of steam for heating and processes and allied questions must be studied in detail. On the other hand, to make a thorough inquiry into future cost of purchased power, it is not enough to glance over the rates for electric current as offered. Liability to interruptions of service, load and power factors, cost of transformation, change of motors (sometimes), damages due to the interruption of manufacture, cost of separate generation of steam for heat and processes—these and similar and varied subjects must be foreseen and considered.

In an existing isolated plant in a mill or institution, complete and correct data showing both cost and performance are seldom available. This lack of reliable information often handicaps an investigator and from the very beginning introduces uncertainties, inevitable with all estimates, guesses and opinions. Such is the case particularly in smaller installations and in many large plants where there are few or no recording instruments. The first step is to defer the decision until all necessary data are reliably collected for a sufficiently long and representative period of time. A specially trained investigator should be in charge of such a study and be neither connected with the plant organization nor interested in the public-utility company. The practice of permitting the public utility company's representatives to make investigations and reports should be strongly discouraged.

DETERMINING THE COST OF SERVICE

There are two different ways of ascertaining the cost. The first, which we may call retrospective, is based on the data or actual performance as it has been or as it is. The second, prospective, is based on the study as to what this cost could and should be. There is no need here to go any further into the description of the latter method, as in my paper on "Standardization of Power-Plant Cost"[1] it was treated at some length.

Which of these two methods shall be used depends largely on the object of study and on local circumstances. Where isolated plants are not as yet in operation or when the records of past performance are incomplete, unreliable or unavailable, the prospective method must be used. If the aim is to show the difference between the past performance of isolated plants (whether good or bad) and the proposed central-station service, the retrospective method is suitable.

There follows a number of items and the considerations that should be given each:

Fuel: This item shall include also cost of unloading, handling, crushing, analyzing, storing, interest on money tied in fuel stored and all other incidental expenses.

Ash: This item shall similarly include the cost of handling, removing, etc.; in some instances it may represent a credit when ashes are sold or used in the business.

Feed Water: This item includes all expenses in connection with purchase or pumping water, including cost of water treatment by whatever method it is being done.

Supplies: Includes all expenses in connection with furnishing the plant with all such supplies as used in operation; like lubricants, packing, waste, gaskets, cleaning and sanitary materials, stationery and the like, including pro rata of the expenses incurred by purchasing office and storeroom.

Labor: Includes the salary and wages of power-plant employees except coal- and ash-handling crews, but shall not include any pro rata of general management, supervision, time and cost keeping, etc., since as a rule the total expenses of these departments will not be reduced by shutting down the plant and buying power from outside.

Liability Insurance of Employees: This item may be influenced by shutting down the power plant, either one way or another; that is, while a number of employees may be dropped from the payroll, the premium on the manufacturing hands insurance may be raised because of some local conditions.

Insurance of Equipment: Includes such expenses as boiler insurance and inspection, flywheel insurance, and any insurance carried on other machinery and equipment, but not on the buildings. Fire insurance may be affected by the change, and its effect upon the entire institution should be taken into account.

Maintenance: It is a fallacy to assume that the idle plant does not involve cost for upkeep and maintenance. In fact, inoperative machinery deteriorates rapidly and requires constant attention and certain expense. The neglect to keep up the idle equipment will either involve a heavy repair bill when central-station service is discontinued or excessive rate of obsolescence if the sale of the plant is eventually decided upon.

ITEMS OF FIXED CHARGES

Fixed Charges: Whether the plant is idle or in use, it involves certain constant expenditure unless the power equipment is sold, and buildings are devoted to some other productive purposes. The items usually classified as fixed charges are: (1) Rent on land and buildings utilized exclusively for power-manufacturing purposes. This item must include the interest on the investment in buildings and foundations, initial cost of engineering, real estate, and on all other incidental expenses enhancing the original value of the property. Similarly, the depreciation of buildings shall form part of rental expenses. (2) Insurance on buildings devoted to the power purposes and not included under operating insurance. (3) Taxes often are not prorated on the power plant. This should be done to find out whether the assessment due to the idle plant is decreased or not.

When the power equipment is not disposed of, the effect of the following items should be considered:

Interest on equipment presents a complicated problem. Where the cost of power is to be determined, the interest shall be figured on the total amount of money invested in the form of material, labor and various services in connection with their installation, testing, etc. If the power is purchased, a great many of these expenses become useless and only part of the investment can be released as salvage; the interest on the balance, however, remains a burden, which shall be added to the cost of purchased power.

Depreciation of equipment, or more correctly, the allotment for amortization of equipment value during a certain period of time shall be treated with the utmost care. If plant is discarded, altogether or partly, upon the beginning of the central-station service, the salvage from the sale of all the machinery may be greater, equal or smaller than the unamortized value and shall be either credited or debited to the new plan and the regular interest on the money thus tied up shall be transferred to the item of interest on equipment and treated as such.

OBSOLESCENCE A SERIOUS QUESTION

Obsolescence becomes a serious question when an isolated plant is temporarily replaced by central-station service. With every year's delay of selling the equipment, it becomes more difficult to dispose of obsolete type of power equipment at a fair value, and the loss due to these and similar causes is to be charged against the profit and loss account. As to the obsolescence in the generally accepted sense of the word, no special treatment of this item is required, as it must be evidently the same as depreciation.

The consideration of obsolescence raises an interesting question. If it appears that the power can be purchased cheaper than it can be generated with the existing equipment, this might be due to the obsolete equipment available; in such a case a study should be made, whether or not it is more economical to introduce such changes and additions to the existing plant as would enhance its efficiency and economy (after the financial obligations involved are duly taken care of) to successfully compete with the proposed central-station service rates. Similarly, the high cost of power generated in an isolated plant is often due to the obsolete method in vogue. In such a case it is imperative that prior to the execution of

*Abstract of a paper before joint meeting of the Boston Sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, Apr. 5, 1917.

†Consulting engineer, New York City.

[1]"Power," Feb. 15, 1916.

a contract for the purchase of power, a thorough search be made by an expert to determine whether the changes in methods of power-plant generation, distribution and use are capable of producing a greater economy than those apparently offered by purchase of power from the outside.

The chief factors constituting the cost of purchased power are rates, and expenses coupled with transmission and transformation of current. Very small consumers generally do not deal with the two last items, as they are included in the rates of the public-utility company. Large consumers, however, such as trolley lines, collieries and big mills, must sometimes either construct or maintain, or both, the approach transmission lines, transformers, substations, etc.

To predetermine what the cost of purchased power would be, the existing and anticipated load curves shall be studied first and the following factors made known: (1) Consumption of current (kw.-hr. in 24 hours); (2) maximum peak load and its duration; (3) power factor.

Where load factor and power factor are stipulated in a contract for certain annual consumption, it is likely that with the larger or smaller consumption both load and power factor conditions will be differently determined in the contract. Similarly, with the increased consumption, a reduction on the secondary charge (charge for energy delivered) rates are stipulated (sliding scale rates) but sometimes the sliding rates are so cleverly adjusted that while they appear in plain numbers in the contract they do not make themselves manifest on the bills presented. One of such ways being that the entire reduction of rates occurs within the limit of minimum consumption guaranteed by the contract.

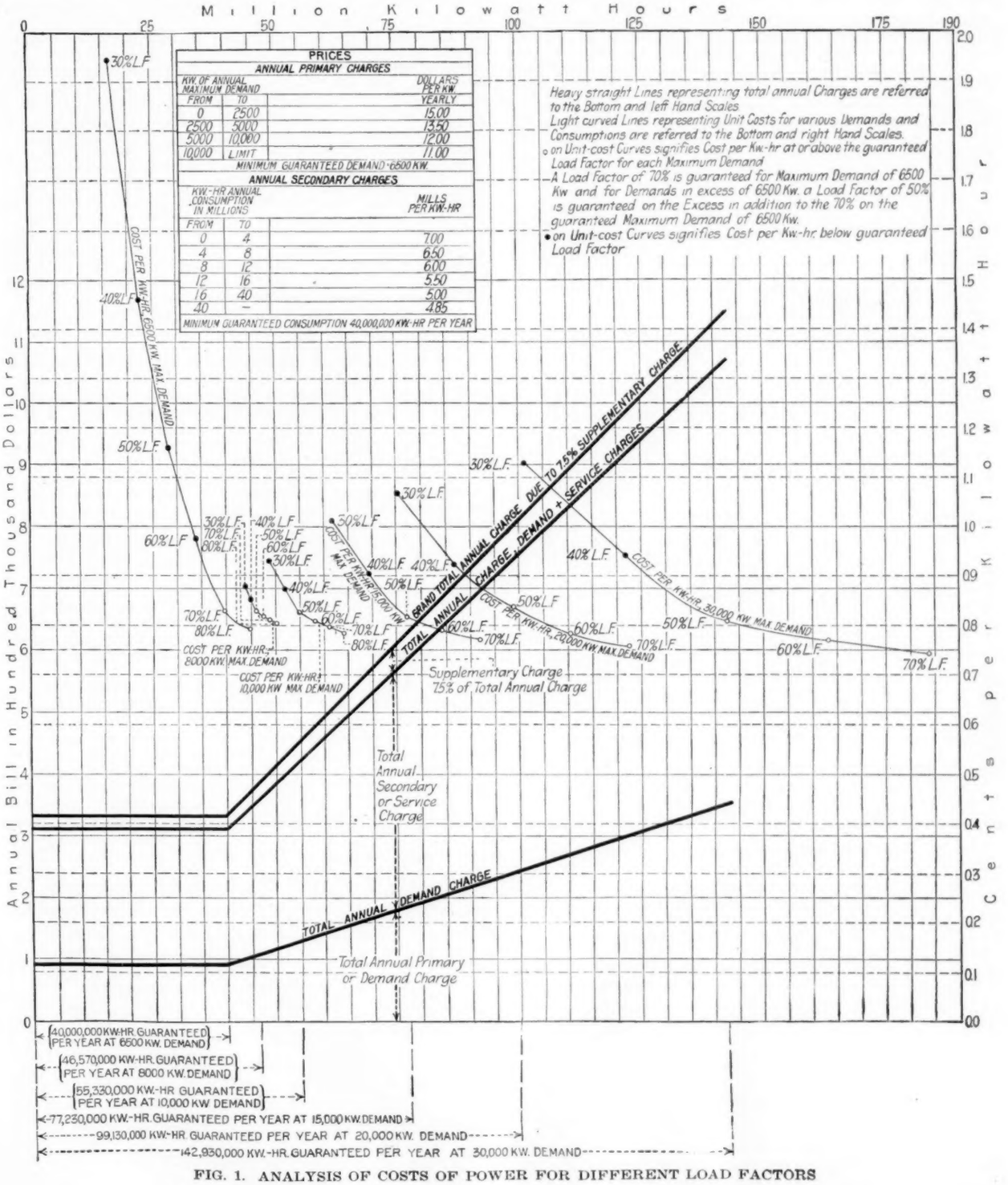

Million Kilowatt Hours
0
25
50
75
100
125
150
175
190
PRICES
ANNUAL PRIMARY CHARGES
KW. OF ANNUAL MAXIMUM DEMAND
FROM
TO
DOLLARS PER KW. YEARLY
0 2500 15.00
2500 5000 13.50
5000 10,000 12.00
10,000 LIMIT 11.00
MINIMUM GUARANTEED DEMAND 6500 KW.
ANNUAL SECONDARY CHARGES
KW.-HR. ANNUAL CONSUMPTION IN MILLIONS
MILLS PER KW-HR
FROM
TO
0 4 7.00
4 8 6.50
8 12 6.00
12 16 5.50
16 40 5.00
40 – 4.85
MINIMUM GUARANTEED CONSUMPTION 40,000,000 KW-HR PER YEAR
Heavy straight Lines representing total annual Charges are referred to the Bottom and left Hand Scales.
Light curved Lines representing Unit Costs for various Demands and Consumptions are referred to the Bottom and right Hand Scales.
o on Unit-cost Curves signifies Cost per Kw.-hr at or above the guaranteed Load Factor for each Maximum Demand
A Load Factor of 70% is guaranteed for Maximum Demand of 6500 Kw and for Demands in excess of 6500 Kw. a Load Factor of 50% is guaranteed on the Excess in addition to the 70% on the guaranteed Maximum Demand of 6500 Kw.
• on Unit-cost Curves signifies Cost per Kw.-hr below guaranteed Load Factor
Annual Bill in Hundred Thousand Dollars
Cents per Kilowatt Hour
30% L.F.
40% L.F.
50% L.F.
60% L.F.
70% L.F.
80% L.F.
COST PER KW-HR. 6500 KW. MAX. DEMAND
COST PER KW-HR. 8000 KW. MAX. DEMAND
COST PER KW-HR. 10,000 KW. MAX. DEMAND
COST PER KW-HR. 15,000 KW. MAX. DEMAND
COST PER KW-HR. 20,000 KW. MAX. DEMAND
COST PER KW-HR. 30,000 KW. MAX. DEMAND
GRAND TOTAL ANNUAL CHARGE DUE TO 7.5% SUPPLEMENTARY CHARGE
TOTAL ANNUAL CHARGE, DEMAND + SERVICE CHARGES
Supplementary Charge 7.5% of Total Annual Charge
Total Annual Secondary or Service Charge
TOTAL ANNUAL DEMAND CHARGE
Total Annual Primary or Demand Charge
40,000,000 KW-HR. GUARANTEED PER YEAR AT 6500 KW. DEMAND
46,570,000 KW-HR. GUARANTEED PER YEAR AT 8000 KW. DEMAND
55,330,000 KW.-HR GUARANTEED PER YEAR AT 10,000 KW DEMAND
77,230,000 KW.-HR. GUARANTEED PER YEAR AT 15,000 KW. DEMAND
99,130,000 KW.-HR GUARANTEED PER YEAR AT 20,000 KW. DEMAND
142,930,000 KW.-HR. GUARANTEED PER YEAR AT 30,000 KW. DEMAND

FIG. 1. ANALYSIS OF COSTS OF POWER FOR DIFFERENT LOAD FACTORS

A graphical method of presenting the contract terms and conditions for both primary charges (charges based on anticipated or connected load) and secondary charges, as worked out by me a few years ago, offers the most convenient and reliable means for studying the effect of conditions on total and unit costs of purchased power.

As it appears in Fig. 1 we plot on the suitable scale curves for

A—Demand charge } annual consumption on abscissa, and
B—Secondary charge } annual charge on ordinates.
C—six curves for unit cost per kw.-hr. for six different rates of consumption at various load factors (annual consumption on abscissa and unit cost on ordinates).

In this particular case it appears that although with the same load factor for any load the cost per kw.-hr. for the entire range drops from 0.86c. to 0.78c. Actually by virtue of the character of service, with 6500 kw. demand, the load factor is 75 per cent., while with 12,500 kw. it is below 60

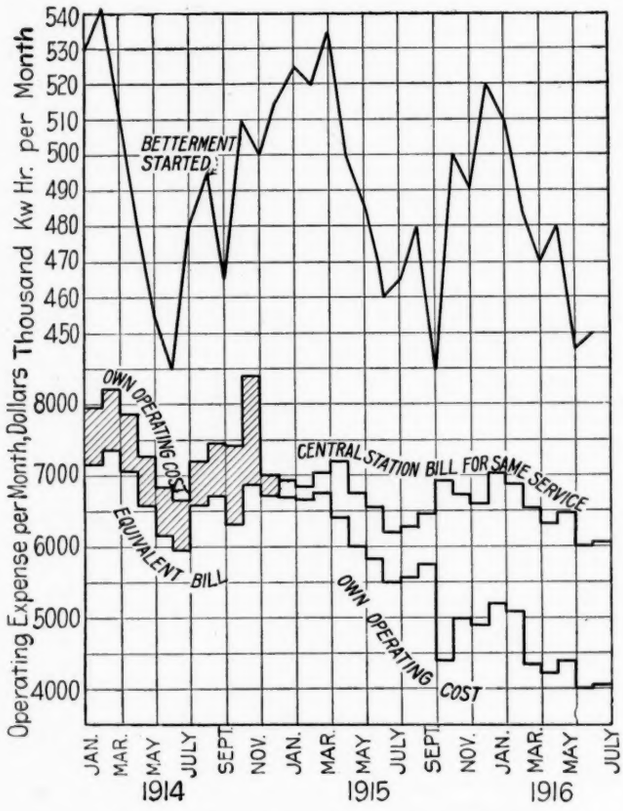


FIG. 2. SHOWING EFFECT OF BETTERMENT WORK

per cent. Under such conditions it becomes evident that for the purchaser the advantage of the sliding scale is illusory, as the unit cost throughout remains about 0.83c. Should this company, instead of buying this large quantity of energy, generate it in its own plant, its own unit cost would drop from $0.58 to $0.44 per kw. within the above limits of consumption.

When the power is purchased for operation of mines or railways or by similar consumers operating over a large territory, it sometimes becomes necessary to construct a special transmission line, and different forms of agreement would treat differently the expenses incidental to its construction and maintenance. A similar situation exists in regard to substations, transformer houses, etc. Whenever the consumer bears part of such expenses, it is clear that they, together with the interest, insurance, rent and other charges, should be added to the cost of purchased power. Likewise, if only ground for structures is offered by the purchaser to the public-utility company for such structure as they need to reach the customer, it is necessary to know the value of this land, etc., and charge the rent, taxes, etc., to the cost of purchased power.

Transformation of the purchased power is another element of cost frequently overlooked in comparisons. The expenses of this group are sometimes considerable and could be roughly enumerated as follows: Wages of attendants; supplies; maintenance to buildings; rent; transformer losses.

The last depends of course on which side the meters are located. In conjunction with this question, if area of ground served is large (as for railways), an inquiry should be made into the extent of losses due to drop of voltage in lines and allied factors. This can be made only in comparison with the supplanted source of power when the location of one has decided advantage over the other, being nearer the center of distribution. These losses should be figured not on the basis of cost of production or of purchased price if current is bought, but on the basis of the system to whose disadvantage the new system would result.

It should not be forgotten that the bill for the purchased power, predetermined as above, is by no means the only expense chargeable against purchased power. Several items of expense incurred in conjunction with the cost of generating power in the private plant should be charged against cost of purchased power; as for instance, rent, interest, depreciation, etc., of the idle plant and similar expenses which are not discontinued after the plant is shut down. These items vary, depending on whether the old plant is discarded altogether or preserved idle or used partly for such service as heating, making steam for processes, and such other purposes that cannot be accomplished by electrification. Again, certain other items can either be credited or become supplementary charges to the purchased power; such as ashes, for instance, which item might be a saving if previously the removal of ashes was an expense, or a loss if the ashes were sold to the contractors or used about the plant.

It is similarly uncertain whether such items as taxes, insurance, administration, pro rata will enhance or reduce the cost of purchased power.

Furthermore, when discontinuation of own service is contemplated, it is often the case that some of the motors and other electrical equipment shall be changed to suit the characteristics of purchased current. These alterations and additions in electrical equipment, reduced by the value of salvage, shall bear a regular rate of interest and other usual charges like depreciation, rent on space and buildings occupied, etc. These expenses should be charged also against the cost of purchased power. Sometimes the changes necessary to receive and start using the purchased power cause interruption in the regular business of the mill or institution. The financial loss resulting from such an interruption should be capitalized and charged against business profit and loss account, as this has no bearing on tangible engineering and financial advantages of one plan or another.

Whether the power, as generated in 90 per cent. of the mills, is cheaper or more expensive than the power the owners could buy, we have no assurance. One does not know without investigation whether a particular case is one of the 90 per cent. or one of the 10 per cent.

While in most cases isolated plants are offering material advantages to the manufacturers, it is true that most isolated plants could be operated at two-thirds or even one-half of their present operating costs if only modern methods were adopted. See Fig. 2. It is nevertheless correct that the generation of power by large central stations possesses unquestionable advantages from a thermodynamic standpoint, as saving natural resources, and offering greater flexibility and protection to the consumers. But these must be made to serve communities as reasonably as municipal stations.

National and State Conventions

American Order of Steam Engineers, Philadelphia, June 4-8.
Canadian Association of Stationary Engineers, July 24-26.
Universal Craftsmen Council of Engineers, Toledo, Ohio, Aug. 5-11.
National Association of Stationary Engineers, Evansville, Ind., Sept. 10-15.

N. A. S. E. STATE ASSOCIATIONS

California	San Jose	June 22-24
Illinois	Moline	June 14-16
Indiana	Evansville	Sept. 10-15
Iowa	Davenport	June 14-16
Kansas	Manhattan	May 2-4
Kentucky	Henderson	Sept. 8, 9
Michigan	Detroit	June 27-29
Minnesota	St. Paul	Aug. 8-10
New England States Association	Portland, Me.	June 28-30
New Jersey	Hoboken	June 2, 3
New York	Rochester	June 14-16
Ohio	Columbus	June 21-23
Pennsylvania	Sharon	June 21-23
Texas	Fort Worth	
Wisconsin	Milwaukee	July 19-21

Ice Jam Damages Coon Rapids Dam—On April 4 an ice jam, said to have been two miles long, carried away ten gates of the Coon Rapids hydro-electric development which supplies Minneapolis and other cities served by the Northern States Power Co. The actual damage is small, and none of the communities experienced anything but a brief interruption of service, as the Riverside steam-generating station at Minneapolis was immediately placed in service.

Military Books for Engineers

A. MILITARY POLICY, CONDUCT OF WAR AND MILITARY HISTORY

The following abbreviations are used: Supt. of Docs., Superintendent of Documents, Government Printing Office, Washington, D. C. Book Dept., Book Department, Army Service Schools, Fort Leavenworth, Kan.

1. OFFICIAL BULLETIN, Vol. 1, No. 2, Office of the Chief of Staff, Washington, D. C. (Especially pp. 21-39.) Publisher: Army War College, Washington, D. C. Free. (An official outline of the theory under which our forces are to be organized and administered.)

2. MILITARY POLICY OF THE UNITED STATES. Upton. May be obtained from Supt. of Docs.; paper, 50c.; cloth, 65c. (A most valuable and comprehensive review of this subject.)

3. FIELD SERVICE REGULATIONS, 1914. May be obtained from Supt. of Docs.; 60c. (A condensed official statement of principles, methods and details of military operations.)

4. ELEMENTS OF STRATEGY. Fieberger, Publisher: U. S. Military Academy, West Point, N. Y. May be obtained from Book Dept.; 75c. (A short outline, with historical illustrations.)

5. CONDUCT OF WAR. Von der Goltz; translated by J. Dickman, Hudson Publishing Co., Kansas City, Mo. May be obtained from Book Dept.; $1.70. (The standard work on this subject, covering generally the same ground as 4, but more abstractly and elaborately.)

6. ON WAR. Clausewitz; translated by J. J. Graham; 3 vols.; K. Paul, Trench, Trubner & Co., 1908. May be obtained from Book Dept.; $6.60 (including postage and duty). (The greatest classic on the subject; a complete analysis of the phenomenon of war, and profound discussion of the mechanism thereof. Written early in the 19th Century, it is still the foundation of modern military theory.)

6½. THE NATION IN ARMS. Von der Goltz. May be obtained from Book Dept.; $2.50. (An excellent modern work on war; less elaborate but more readable than Clausewitz.)

7. AMERICAN CAMPAIGNS. M. F. Steele; 2 vols. Publishers: Byron S. Adams Publishing Co., Washington, D. C. May be obtained from Book Dept.; $4.50. (In addition to careful historical surveys of all the campaigns from the Colonial Wars to the Spanish American War, these lectures give extensive and valuable comments as to the military principles.)

8. A STUDY OF ATTACKS ON FORTIFIED HARBORS. Rodgers; Proceedings Nos. 111, 112 and 113, United States Naval Institute, Annapolis, Md.

9. LESSONS OF THE WAR WITH SPAIN. Mahan. Publishers: Little, Brown & Co., Boston, Mass. May be obtained from Book Dept.; $2. (Of special importance, as showing the true relation between our coast defense and our navy.)

10. REPORTS OF MILITARY OBSERVERS ON THE RUSSO-JAPANESE WAR. Part III, J. E. Kuhn. May be obtained from Supt. of Docs.; 60c. (In addition to an account of operations, this report contains valuable information as to fortification and siege work, organization and equipment.)

11. ORGANIZATION AND OPERATION OF THE LINES OF COMMUNICATION IN WAR. Furse, 1894. Publishers: Wm. Clowes & Sons, Ltd., London. (An old but comprehensive survey of this subject, with much historical information.)

B. PERMANENT FORTIFICATIONS

(The references given cover chiefly the principles and general features of this subject; the details are mostly printed in unavailable form, either in service journals or in confidential documents. References to some of the former can be furnished, if desired.)

12. REPORT OF NATIONAL COAST DEFENSE. (Taft) Board, 1906. May be obtained from Army War College, Washington, D. C. Free. (The official project for harbor defenses of the United States. On account of progressive obsolescence of seacoast defenses, this project has been, or is being, modified, but still sets forth clearly the fundamentals.)

13. LECTURES ON SEACOAST DEFENSE. Winslow. Publishers: United States Engineer School, Washington Barracks, D. C. Price, 50c. (Much of these lectures relates to technical details, and a considerable part is now obsolete.)

14. PERMANENT FORTIFICATIONS. Fieberger, 1900; United States Military Academy, West Point, N. Y.; $1. May be obtained from Book Dept. (While rather old, this work gives a simple presentation of the fundamentals on its subject, including an historical outline. A revised edition will soon be published.)

15. FORTIFICATIONS. C. S. Clarke. Dutton & Co., New York; $4.50. May be obtained from Book Dept. (A treatise on the same lines as 14.)

16. PRINCIPLES OF LAND DEFENSE. Thuillier, 1902; Longmans, Green & Co. May be obtained from Book Dept.; $3.83. (A valuable work, covering the principles of both field and permanent fortification.)

C. ORGANIZATION, EQUIPMENT AND DUTIES OF ENGINEER TROOPS

17. FIELD SERVICE REGULATIONS, 1914. (See A. 3.)

18. TABLES OF ORGANIZATION, 1914. May be obtained from Supt. of Docs.; 25c. (These tables represent—subject to modification and within the limits of existing law—the approved policy of the War Department with regards to organization.)

19. OFFICIAL BULLETIN, Office of the Chief of Staff, Vol. 1, No. 4 (Appendix 4). Use of Engineer Troops. Publisher: Army War College, Washington, D. C. Free. (An official statement of the principles which should govern in the use of engineers, with practical suggestions.)

20. DUTIES OF ENGINEER TROOPS IN A GENERAL ENGAGEMENT OF A MIXED FORCE. Burgess. Publisher: United States Engineer School, Washington Barracks, D. C.; 25c. (Obsolete in some respects, particularly organization, but excellent in general scope.)

21. GENERAL ORDERS NO. 6, WAR DEPARTMENT, 1915. May be obtained from the Adjutant General, United States Army, Washington, D. C. Free. (Prescribes the training of Engineer troops.)

22. STUDIES IN MINOR TACTICS. Army Service Schools, 1915. May be obtained from Book Dept.; 50c. (The principles of Minor Tactics are set forth by solution of a series of problems.)

23. TECHNIQUE OF MODERN TACTICS. Bond & McDonough, 1914; Banta Publishing Co., Menasha, Wis. May be obtained from Book Dept.; $2.55. (This work covers, in a very specific way, the principles of tactics for all arms, a general knowledge of which is essential for engineers.)

24. OPERATION ORDERS. Von Kiesling; translation. May be obtained from Book Dept.; 50c. (A lucid exposition, by use of assumed cases, of the operation of highly trained troops of all arms in various phases of battle.)

25. ENGINEER UNIT ACCOUNTABILITY MANUAL. May be obtained from Supt. of Docs.; 5c. (Official lists of standard equipment supplied to Engineer battalions and companies.)

26. ORGANIZATION OF THE BRIDGE EQUIPAGE OF THE UNITED STATES ARMY, 1915. (Revised edition just going to press.) (Includes description of equipage and regulations for ponton drill.)

27. OFFICERS' MANUAL. Moss; Banta Publishing Co., Menasha, Wis.; $2.50. May be obtained from Book Dept. (Treats of routine duties of officers, customs of the service, army organization, etc.)

28. MANUAL FOR COURTS MARTIAL. May be obtained from Supt. of Docs.; 50c.

D. FIELD ENGINEERING

(Military field engineering at the front differs from ordinary engineering work in the field, it being generally simpler, of a rough-and-ready character, and especially because of the limited equipment which can be taken along with the advance of an army and because of the necessity of working in strict subordination to the military situation. In rear of the army on the contrary, conditions are very similar to those governing ordinary engineering operations, and civilian organization is suitable, subject to directions by the higher military staff. Little attempt is made in works on military field engineering to treat of general engineering methods.)

29. FIELD FORTIFICATION. Fieberger, 1913; John Wiley & Sons, New York. May be obtained from Book Dept.; $1.90. (In addition to technical details, this work gives valuable historical illustrations of the principles of this subject.)

30. FIELD ENTRENCHMENTS, SPADE WORK FOR RIFLEMEN. John Murray, London. May be obtained from Book Dept.; 40c. (A very uptodate little work, especially on details.)

31. NOTES ON FIELD FORTIFICATION. Army Field Engineer School. May be obtained from Book Dept.; 30c.

32. ENGINEER FIELD MANUAL. Professional Paper No. 29, Corps of Engineers, United States Army; 3d edition, 1909. 500 pages. May be obtained from Supt. of Docs.; $1. (A very complete official pocketbook for engineer officers in the field, containing much tabular and technical data, as well as brief outlines of principles and methods. The subjects covered are, Part I, Reconnaissance; Part II, Bridges; Part III, Roads; Part IV, Railroads; Part V, Field Fortification; and Part VI, Animal Transportation. A new revision of the manual is contemplated, but will not be ready within a year. The portion of the manual relating to field fortification, being somewhat obsolete, should be considered in connection with either 30 or 31 above. The portion relating to railroads is largely superseded by 35 below.

33. NOTES ON BRIDGES AND BRIDGING. Spalding. May be obtained from Book Dept. (A small pamphlet on military bridging.)

34. MILITARY TOPOGRAPHY FOR MOBILE FORCES. Sherrill, 2d edition; Banta Publishing Co., Menasha, Wis., 1911. May be obtained from Book Dept.; $2.25. (Besides matter given in ordinary textbooks on surveying, this work gives in detail the special methods of sketching developed in the army for rapid military mapping.)

35. MILITARY RAILROADS. Connor; Professional Paper No. 32, Corps of Engineers, United States Army. Supt. of Docs.; 50c. (Intended to cover general administration of existing railroads for military purposes and the handling of railroads by military personnel in the advance sections where railroads cannot be operated by their regular civilian organizations, or where new railroads are required in the immediate vicinity of the army. Revised edition soon to appear.)

36. NOTES ON MILITARY EXPLOSIVES. Weaver; J. Wiley & Sons, New York; 1912. May be obtained from Book Dept.; $3.25. (Elementary notes on this subject will be found in the Engineer Field Manual and other references cited. This work is more elaborate.)

E. MISCELLANEOUS

37. REGULATIONS FOR THE ARMY OF THE UNITED STATES. Supt. of Docs.; 50c.

38. THE "VOLUNTEER LAW," approved Apr. 25, 1914; Bulletin No. 17. War Department, 1914. May be obtained from The Adjutant General, United States Army, Washington, D. C. Free.

39. GENERAL ORDERS NO. 54, War Department, 1914. May be obtained from The Adjutant General, United States Army, Washington, D. C. Free. (Covers examination of candidates for commissions as officers of volunteers.)

40. GENERAL ORDERS NO. 50, War Department, 1915. May be obtained from The Adjutant General, United States Army, Washington, D. C. Free. (Amends General Orders 54, 1914,

as to examination of candidates for commissions in volunteer engineers.)

41. TREATISE ON MILITARY LAW. Davis; John Wiley & Sons, New York. May be obtained from Book Dept.; $5.30.

42. ELEMENTS OF MILITARY HYGIENE. Ashburne; new edition; Houghton, Mifflin & Co., Boston, 1915. May be obtained from Book Dept.; $1.30.

F. PERIODICALS

43. PROFESSIONAL MEMOIRS. Corps of Engineers, United States Army, and Engineer Department at Large; bimonthly (formerly quarterly); Washington Barracks, D. C., Engineer Press; per year, $3.

44. THE ROYAL ENGINEERS' JOURNAL. Royal Engineers Institute, Chatham, England; monthly; per year, $4. (American agents; E. Steiger & Co., 49 Murray St., New York.)

45. JOURNAL OF THE MILITARY SERVICE INSTITUTION, Governors Island, New York. Bimonthly; published by the Institution; per year, $3.

46. JOURNAL OF THE UNITED STATES ARTILLERY. Bimonthly; Fortress Monroe, Va., Coast Artillery School Press; per year, $2.75, including Index to Current Literature; without Index, $2.50.

47. JOURNAL OF THE UNITED STATES CAVALRY ASSOCIATION. Published by the Association at Fort Leavenworth, Kan.; per year, $2.50.

48. INFANTRY JOURNAL. Bimonthly; published by the United States Infantry Association, Union Trust Building, Washington, D. C.; per year, $3.

49. FIELD ARTILLERY JOURNAL, quarterly; published by the United States Field Artillery Association, 601 Star Building, Washington, D. C.; per year, $3.

Engineers Protest Against Relaxation of Massachusetts License Law

Various organizations of engineers and firemen made a vigorous "drive" at Boston, Mass., May 3, against Senate Bill 519, a measure planned to relax the Massachusetts engineer's licensing law in the interests of manufacturers and other employers on the claim that the war threatens to impose a shortage of power-plant labor. Richard B. Stanley, for the Arkwright Club, an organization of New England textile men, was the first speaker before the committee on mercantile affairs, which has the bill in charge. He explained the provisions of the bill, under which special licenses may be granted (during the war) an applicant to operate a particular steam plant following an examination as to the applicant's competence, and regardless of the usual 150-hp. minimum applying to a first-class license, stating that a man might be competent to handle one plant and yet be unable to handle another. The existing law allows special licenses to be granted up to 150 hp. The advocates of the bill favor extending it to six months beyond the close of the war, in order to provide for readjustments of labor after the conflict is over.

Randall N. Durfee, of the Bordon City Manufacturing Co., Fall River, author of the bill, said that mills are now engaged on Government contracts and any interruption of service would be most undesirable; that at present there is a shortage of licensed firemen in his own plant and the mills have already lost several engineers who have been called into military or naval service; that about twenty engineers and firemen have left Fall River for this service to date.

W. N. McLane, treasurer of the Seaconnet Mills, Fall River, said that one fireman who is a gunner has left his plant and that his pay will go on while he is away. At present 12 per cent. of the productive capacity of these mills is occupied on Government work, and soon this will be increased 25 to 50 per cent. The owners do not want the Government to commandeer the mills, preferring to run the plant themselves, devoting all possible energies to the filling of Government orders. The mill owners feel it important to guard against any future shortage of engineers.

A. E. Pillsbury, for the Association of Massachusetts Gas companies, and W. O. Wood, chief engineer of the Boston Consolidated Gas Co., also favored the bill. E. W. Burdett, for the Massachusetts Gas and Electric Lighting Association, said that competent men are always in the employ of the gas and electric-light companies who can take charge of the boilers and engines, but who cannot pass either a written or an oral examination. The speaker said that the electric-lighting and gas plants must continue to give service no less than the railroads and other public utilities. S. L. Powers, for the American Woolen Co., said that this concern operates 17 mills in Massachusetts and employs about 24,000 operatives. It is now making cloth for uniforms. Engines or turbines of over 150-hp. rating are in use in nearly all these mills, and the company wishes to be sure of a supply of engineers and firemen in order to carry out its obligations to the Government.

Dudley G. Kimball, Boston, for the N. A. S. E., said that the number of special licenses is being continually reduced with good results and referred to a disastrous explosion that occurred at Brockton a few years ago where 58 persons were killed, 217 injured and $500,000 lost, that might have been prevented had a competent engineer been on the job. The speaker protested vigorously against lowering the standards of ability with respect to the operation of power plants. There are, he said, 200 first-class licensed engineers within a 5-mile radius of Boston, and some of these are firing because there are not enough plants of the first order to give them employment at their proper rating. There are some 50,000 engineers' and firemen's licenses outstanding in Massachusetts, and there are but 20,000 boilers in service in the state. Most of the men operating engines of over 150-hp. rating are over 40 years of age, and consequently are not subject to military draft. He doubted if one-half of 1 per cent. of the first-class engineers would be drafted for military service. He claims that the introduction of the bill would flood the market with incompetent men. Citing the importance of a rigid code of boiler and engine licenses, he said that in the United States, in 1914, there were 575 boiler explosions and 300 were killed and 476 injured.

Tests of qualifications for marine engineers are not being lowered by the Government at this time. The N. A. S. E. membership is opposed to the bill as one man, and there are thousands of licensed engineers who would be glad to return to their former occupation if needed. Taking up Fall River as a special case, the speaker said that there is no shortage of engineers in that city and that licensed men can be sent to any point promptly when needed. Wages are higher for the same class of work in some other cities, and this is one reason why men leave Fall River. About 300 engineers a year are placed through the organization, and the leaders feel confident that any demand can be supplied.

H. M. Comerford, for the Massachusetts state branch of the International Union of Steam and Operating Engineers, said that there is no shortage of first-class men. He condemned the bill as an effort on the part of the manufacturers to procure licenses for their master mechanics under the guise of war needs. He said that a bill now in the legislature is designed to give the governor of Massachusetts practically unlimited power of action during the war, making it possible to meet any emergency that may arise in the employment of power-plant workers. Joseph Egleston, New England States Association of Stationary Engineers, New Bedford, Mass., said that it takes ten years to produce a first-class engineer, and that the lower grades are more easily produced for service under a first-class man. He felt that a special license would be a dangerous weapon in the hands of the plant owner. E. J. Sheehan and W. M. Beck, for the International Union, also opposed the bill.

Machinery Needed for Wooden Ships*

While nothing definite has been given out as to the final decision concerning the new fleet of wooden ships, there seems to be little doubt that the following figures will be found approximately correct. Length, 275 ft.; width, 46 ft.; molded depth, 26 ft.; and draft 23 ft. The main propelling engines will be triple-expansion of either 750 or 1500 i.hp. units, which will give a normal speed of 10 knots, with a reserve large enough to bother a U-boat in catching them in a long chase. Turbines may also be used in some of them, but it is probable that reciprocating engines will predominate, unless oil engines of the Diesel or semi-Diesel type can be secured, which seems doubtful.

The boilers will be of both the water-tube and the Scotch types, will carry 200 lb. pressure, and have perhaps 15 per cent. excess over the rated engine power.

The necessary machinery will include that of any ocean-going vessel, such as propellers, condensers, air pumps, circulating pumps, boiler-feed pumps, fuel-oil burning apparatus, evaporators feed-water heaters, forced-draft apparatus, fuel-oil tanks, refrigerating apparatus, piping and fittings, generator sets, wireless apparatus, steering engines, capstans, windlass anchors and anchor chains, davit wire and hemp rope, navigating apparatus, etc.

Those in a position to supply any of this equipment complete, or any part of it, would do well to get in communication with the Shipping Board at once, Munsey Building, Washington, D. C., as according to present indications there will probably be at least a thousand of these ships built within the coming year.

*From our Washington representative.

Report of N. E. L. A. Convention

In lieu of the canceled Atlantic City convention, the National Electric Light Association held a two-day session at its headquarters in New York on May 9 and 10 primarily for the purpose of discussing means by which the electrical industry may best adjust itself to the present conditions and at the same time be of greatest service to the Government.

In the opening address, President H. A. Wagner recalled that the N. E. L. A. membership, which now numbers over 15,000, includes not only specialists on electric production but on its industrial applications, and they therefore are a very potent factor in the present emergency. Now is the time for closer coöperation between the electrical and the gas industries; and the association, he believed, might give more specific help and information to the smaller company members. He dwelt at some length on the relations of the public and the utilities companies, pointing out that they have common interests and that public-service regulation has done much to establish the proper relations.

A brief report by the Secretary T. C. Martin was followed by the report of the Public-Policy Committee, read by Mr. Freeman.

John W. Lieb, of the New York Edison Co., then spoke of some of the problems now confronting the central stations. Among the most acute at present is the coal situation and the difficulties in procuring deliveries of apparatus to meet the increasing load demands. It may become necessary to curtail certain services to render available capacity for the more urgent needs of the manufacturers of war materials. The labor situation is another problem of the hour. Some plan must be worked out, compatible with the conscription and enlistment, that will not deprive the central stations of skilled men. The speaker outlined some of the experiences of the warring nations in this connection, particularly regarding the employment of female labor. Lastly, he touched upon the problem of protecting company property, saying that it is now costing the New York Edison Co. $1000 a day to guard its stations and system.

Major Finney, of the Engineers' Reserve Corps, spoke briefly on the work of the National Council of Defense and how the electrical industry might coöperate.

The afternoon session was called to order by President Wagner, who delivered a short address calling attention to the important position of the central station in this great crisis, not alone in supplying energy for light and power purposes, but also in bringing the great national problems before the public. Mr. Wagner then introduced Mr. Allen Walker, personal representative of the Chamber of Commerce, Washington, D. C., who addressed the meeting on how the many industrial problems arising out of the war could best be solved. The speaker called particular attention to the ways our allies in Europe found it necessary to solve them. After Mr. Walker's address the meeting was devoted to a general discussion of the morning's address and the formulation of recommendations to member companies for the conduct of their affairs in relation to the Government's plans for raising military forces and mobilizing the nation's industries, during which D. H. McDougall, of the Toronto Electric Light and Power Co., Canada, gave a very interesting talk on the part Canada had taken in the war and how the power companies had solved their problems.

The third and last session was held Thursday morning, with President H. A. Wagner presiding. The report of the Committee on Constitution and Bylaws was presented and the changes in the constitution adopted as presented. The chief change was:

> The object of this Association shall be to foster and protect the interests of those engaged in the commercial production of electricity for conversion into light, heat or power, and of their customers.

But as changed and adopted reads:

> The object of this Association shall be to advance the art and science of the production, distribution and use of electricity for light, heat and power for public service.
>
> In the furtherance of this object its activities shall be largely educational and for the fullest development of the electrical engineering arts and sciences in all their branches. It shall not be engaged in business.

The entire program of papers and committee reports for the annual convention, as published in the April issue of the "N. E. L. A. Bulletin," which was to be presented at the Atlantic City Convention May 28 to June 1, was adopted, subject to the approval of a committee, for publication in the proceedings.

Michigan Board of Boiler Rules—A bill which provides for the creation of a Board of Boiler Rules, appointed by the governor of the State of Michigan and carrying with it a provision for the adoption of the A. S. M. E. Code, has passed the Senate and House and was signed by the governor May 3.

ENGINEERING AFFAIRS

The American Order of Steam Engineers will hold its 31st annual convention at Philadelphia, Penn., June 4-8.

The St. Louis (Mo.) Section of the A. S. M. E. will hold a meeting on May 16. W. R. Blair will talk on "The Measuregraph."

The Chicago Section of the A. S. M. E. will hold a meeting on May 18. O. B. Zimmermann will speak on "Small Internal-Combustion Engines."

The Ohio Electric Light Association will hold its annual convention at Cedar Point, Ohio, July 16-20, with headquarters at the Breakers Hotel.

The Society of Automotive Engineers will hold a meeting at the Automobile Club of America, New York City, on May 17. H. G. Chatain is expected to talk on the Diesel engine, and Mr. Scott on the Junker engine.

The Combined Associations of Brooklyn N. A. S. E., Nos. 8, 15, 27, 41 and 57, will hold a musicale and entertainment in the hall of the operating engineers' building, 125 So. Elliot St., on Saturday evening, May 19. Addresses will be given by prominent members of the organizations during the evening. Brother engineers of greater New York are invited.

New York Engineer's Protective Society held its regular semi-monthly meeting at its meeting room in the Bloomingdale Building, 60th St. and 3rd Ave., New York City, on Saturday evening, May 5. A. R. Trezise, of the Otis Elevator Co., gave a very interesting talk on hydraulic and electric elevators. Mr. Trezise briefly reviewed the early history and development of hydraulic and electric elevators, and then by the use of a large number of lantern slides showed the evolution in the mechanical and electrical features of the electrical elevator that has led up to the high-speed traction machine, which solved the transportation problems in the modern skyscraper office building.

The American Society of Mechanical Engineers will hold its spring meeting at Cincinnati, Ohio, May 21-24, with headquarters at the Hotel Sinton. On Monday morning the meeting will open and registration will take place; there will be local inspection trips in the afternoon and an informal reception in the evening. On Tuesday morning there will be a business meeting, followed by professional sessions at which the following papers will be read: "A Foundation for Machine Tool Design and Construction," by A. L. De Leeuw; "Machine Shop Organization," by Fred G. Kent; "Metal Planers and Methods of Production," by Charles Meier. These will be read at the machine shop session. At the general session the following papers will be read: "Tests of Uniflow Steam Traction Engines," by F. W. Marquis; "Relation of Efficiency to Capacity in the Boiler Room," by Victor B. Phillips; "Radiation Error in Measuring Temperature of Gases," by Henry Kreisinger and J. F. Barkley; "Development of Scientific Methods of Management in a Manufacturing Plant," by Sanford E. Thompson and associates; "Disk Wheel Stress Determination," by S. H. Weaver. In the afternoon there will be an excursion for the ladies to Rockwood Pottery and the Art Museum; also a joint session with National Tool Builders' Association, with two addresses: "The Trend in Engineering Training," by Dean Herman Schneider; "The Human Potential in Industry," by Dr. Otto P. Geier. Later there will be a trolley ride for the ladies to Fort Thomas; a smoker for members of the society and of the National Machine Tool Builders' Association, and a reception for the ladies in the evening. Wednesday's program will open with the first munitions session. The opening remarks will be made by Major E. D. Bricker, ordnance department, Frankford Arsenal, and Lieut. T. S. Wilkinson, Jr., U. S. N. Bureau of Ordnance. There will be a boat ride to Fern Bank dam or water-works in the afternoon and an informal dance in the evening. Thursday will open with simultaneous sessions, including the second munitions and the gas-power session. Papers at the latter will include: "The Problem of Aëronautical Engine Design," by C. E. Lucke; "Test of a Motor Fire Engine," by Horace Judd; "Design of Motor Truck Engines for Long Life," by John Younger; "Relation of Port Area to the Power of Gas Engines and Its Influence on Regulation," by J. E. Du Priest. At the industrial safety session the "Proposed Code of Safety Standards for Industrial Ladders" will be discussed. In the afternoon there will be a motor-car ride to Mt. Storm, U. C. Observatory, Ault Park, and visits to machine plants; and on Friday for those who remain over there will be trips to Fort Ancient, Mammoth Cave, or to Lexington.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	May 12, 1917	One Year Ago	May 12, 1917	One Year Ago
Buckwheat	$3.40—4.40	$3.05—3.20	$6.50—6.75	$3.25—3.50
Rice	.....	2.50—2.65	5.50—5.75	2.70—2.95
Boiler	.....	.....	4.25—4.50	.....
Barley	2.65—3.65	2.20—2.35	4.15—4.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	May 12, 1917	One Year Ago	May 12, 1917	One Year Ago
Clearfields	$5.25—6.00	$1.20—1.65	$11.00—11.50	$4.25—5.00
Cambrias and Somersets	5.50—6.25	1.50—1.95	11.25—11.75	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $7.00—7.50, as compared with $2.75—2.85 a year ago; on cars Boston price is $12.50—13.00.
*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	May 12, 1917	One Year Ago	May 12, 1917	One Year Ago
Buckwheat	$4.00—4.15	$2.75	$6.75—7.00	$3.00—3.25
Rice	3.40—4.05	2.25	5.00—5.25	2.15—2.25
Barley	2.90—3.10	1.75	3.50—3.75	2.00—2.10

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$7.00—7.50	$7.00—7.50	$5.25—5.75
South Forks	7.25—7.50	.....	5.50—6.00
Nanty Glo	7.25—7.50	.....	5.50—6.00
Somerset	7.00—7.25	7.00—7.25	5.25—5.75
Quemahoning	7.25—7.50	7.25—7.50	5.50—6.00

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	May 12, 1917	One Year Ago	May 12, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3.40	$2.55
Rice	2.00	.90	3.00	1.80
Boiler	1.80	....	2.90	....
Barley	1.50	.55	1.75	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	May 12, 1917	One Year Ago
Slack	$4.50	$0.95—1.05
Mine-run	4.50	1.25—1.35
¾-in.	4.50	1.35—1.45

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$3.00—3.50	$3.00—3.25	$5.00—5.25	$2.25—2.75	$2.50—3.00
Lump	3.25—3.50	3.25—3.50	5.00—5.50	2.50—3.00	2.75—3.00
Egg	3.25—3.50	3.25—3.50	5.00—5.50	2.50—3.00	2.75—3.00
Nut	3.25—3.50	3.25—3.50	.....	2.50—3.00	2.75—3.00
No. 1 nut	3.25—3.50	3.25—3.50	.....	.....	2.75—3.00
No. 2 nut	3.25—3.50	3.25—3.50	.....	.....	.....
No. 3 nut	2.75—3.00	2.50—3.00	.....	.....	.....
No. 1 washed	3.25—3.50	.....	.....	.....	.....
No. 2 washed	3.00—3.50	.....	.....	.....	.....
Mine-run	2.75—3.00	2.50—2.75	5.00—5.25	2.25—2.50	2.00—2.50
Screenings	2.75—3.00	2.50—2.75	.....	2.25—2.50	2.00—2.50

Hocking lump, $4.25—4.50; splint lump, $4.00—4.50.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	May 12, 1917	One Year Ago	May 12, 1917	One Year Ago	May 12, 1917	One Year Ago
6-in. lump	$3.75—4.00	$1.35—1.45	$2.50	$1.75	$2.50	$1.10
2-in. lump	3.75	1.25—1.35	2.50	1.20	2.35	.90
Steam egg	3.75	1.25—1.35	2.50	1.20	2.35	.90
Mine-run	3.25	1.25	2.25	1.10	2.25	.90
No. 1 nut	3.75	1.40	2.50	1.20	2.50	.90
2-in. screen	2.75	1.00	2.25	.95	2.25	.95
No. 5 washed	2.75	1.00	2.25	.95	2.25	.90

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.50—4.00	Carbon Hill	$3.00—3.25
Big Seam	2.75—3.00	Cahaba	3.50—4.00
Black Creek	3.50—4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ark., Ft. Smith—The Ft. Smith Light and Traction Co. plans to install an electric transmission line from Ft. Smith to Huntington, to furnish electrical service there.

Colo., Ft. Morgan—The Municipal Light and Water Plant is receiving estimates for a new 500-kw. generating unit to be connected either to a reciprocating engine or a steam turbine; also on a deep well, 180 ft. deep, with a vertical centrifugal pump, directly connected to a 50-hp. motor. G. C. Cox, superintendent.

Conn., Clinton—The Clinton Electric Light and Power Co. has been granted permission to issue $100,000 bonds and $70,000 capital stock, to be used for extending the system and for refunding purposes.

D. C., Washington—(Official)—The Bureau of Supplies and Accounts, Navy Department, will soon receive bids for furnishing at the Navy Yard, under Schedule 1086, 5000 gal. heavy petroleum oil and 6000 gal. rapeseed oil.

Iowa, Dyersville—The Eastern Iowa Electric Co. is considering plans for an electric transmission line into Hickory Valley to supply electrical service to farmers in the vicinity. F. W. Altman, 302 Security Bldg., Dubuque, Pres.

Iowa, Elkader—Schidt & Bros. Co. has been granted a franchise to install a transmission line in Clayton and Delaware Counties, including extensions to Boardman, Cox Creek, Volga and Mallory Townships, and towns of Littleport, Garber, Elkport and Colesburg.

Maine, Portland—The Cumberland County Power and Light Co. has applied to the Public Service Commission for permission to issue $440,000 bonds, of which $207,727 for improvement, as follows: Hiram hydro-electric development and transmission lines, $45,000; extensions of lines and services for the year ending Dec. 31, 1917, $35,000; high-voltage tie line between Sewell St. station and Plum St. station, $35,000; extension of transmission lines from Cumberland to Yarmouth, $20,000; 16-way duct line between Sewell St. station and Deering Ave., $32,396; grounding service to existing customers, $6000, and additional voltage regulators to control two additional circuits, $7000. M. A. Williams, 451 Congress St. Pur. Agt.

Mass., Greenfield—The Greenfield Electric Light and Power Co. was granted permission to extend its electric transmission lines to the Northfield Farms. F. L. Hunt, Ch. Engr.

Mich., North Muskogee—The Consumers' Power Co., Jackson, have been granted a franchise to supply electricity in North Muskegon. Company will install a transmission line this summer. C. W. Tippy, Jackson, Gen. Mgr.

Mo., Malta Bend—City plans to install an electric-lighting system.

Mo., Smithville—C. Morton and H. Gordon will rebuild their electric-light plant which was recently destroyed by fire, and will install equipment to cost about $7500.

Mo., Valley Park—City plans to install an electric-lighting system.

Neb., Norfok—The Nebraska Gas and Electric Co., controlled by the Continental Gas and Electric Corp., Cuyahoga Bldg., Cleveland, will construct a transmission line from Norfolk to Hadar and will install a 75-kw. and 100-hp. steam turbine. W. C. Ross, Woodman of the World Bldg., Omaha, Neb., Gen. Mgr.

N. Y., Guilford—The Standard Light, Heat and Power Co., Unadilla, has applied to the Public Service Commission for permission to erect an electric transmission line into Guilford. E. O. Allen, Sidney, Pres., Mgr. and Gen. Supt.

N. Y., Hornell—The Hornell Electric Co. is considering installing a new street-lighting system.

Penn., Steelton—The Harrisburg Light and Power Co. plans to install a new street-lighting system.

Tex., San Angelo—The Texas Electric Light and Power Co., recently incorporated with $200,000 capital stock, will take over the local electric-light and power plant and transmission system and will enlarge the power plant and extend the transmission lines. The company also plans to build and operate a street-railway system in San Angelo and an interurban railway to Ballinger, about 30 mi. C. W. Hobbs, San Angelo, Pres.

Vt., Bristol—The Hortomio Power Co., Rutland, plans to extend its transmission line from Bristol to Monkton, Monktonbridge (North Ferrisburg P. O.) and Hinesburg, to supply electricity in villages named and farms between Brandon and Hinesburg. I. M. Frost, Gryphon Bldg., Rutland, Vice Pres. and Gen. Mgr.

Vt., Newfane—The Twin State Gas and Electric Co. will extend its transmission line from Newfane to Townshend, for which the right-of-way is being secured.

Wash., Bremerton—(Official)—The Bureau of Supplies and Accounts, Navy Department, Washington, will soon receive bids for furnishing at Puget Sound Navy Yard, under Schedule 1078, 1900 keyless lamps, sockets for instruments and 145 spools silk insulating tape.

Wash., Chesaw—W. Powell is reported interested in plans for installing an electric-light and power plant in Chesaw to supply electricity for both street and commercial lighting. The plans have been prepared and are now being considered.

Wash., Long Lake—The Washington Water Power Co., Spokane, plans high-tension transmission line from its power plant to Northport, 90 mi., to supply electricity to mines and other industries. C. F. Uhden, 825 Trent St., Spokane, Ch. Engr.

Wis., Knapp—The Wisconsin-Minnesota Light and Power Co., controlled by the American Public Utilities Co., will install a transmission line into Knapp. A. E. Pierce, Eau Claire, 2nd Vice Pres. and Gen. Mgr.

Wis., Milwaukee—The Milwaukee Protestants Orphans' Asylum, Prospect and East North Ave., will construct a new power and boiler house, 50 x 100 ft., with a 100-ft. stack. Schuchardt & Judell, in charge.